Bindery

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Headquarters for Snow Measurements, Mount Rose, at Contact Pass. Elevation 9,000 Feet.

This Hut was made of Sand Bags Covered with Tar. The roof is a Tarpaulin.

Studying Evaporation with Pan and Anemometer on Cornice at Summit of Mount Rose.

RELATION OF FORESTS TO THE CONSERVATION OF SNOW.—[See page 152.]

A Review of the Physics of Light—III*

Prof. Silvanus P. Thompson's Presidential Address at the Recent Optical Convention in London

Concluded from Scientific American Supplement No. 1913, page 135

PHYSICAL OPTICS.

When we turn to the vast subject of physical optics we cannot but be struck with the variety of phenomena which must be taken into account by anyone who would deal with the nature of light itself, or with the mechanism of the ethereal medium by which it is conveyed. Dispersion[14] and its anomalies, interference, diffraction, the multitudinous effects of polarization, the problems of radiation and luminescence, of opalescence and the blue of the sky, of iridescence and the gorgeous colors of butterflies and humming birds, to say nothing of radioactivity, or of the chemical, physiological, electrical, magnetic, and mechanical relations of light, furnish whole fields in which knowledge is still in the making. In physical optics, though there are mathematical laws, such as those discovered by Fresnel and Stokes, to be mastered, the chief concern is with physical phenomena; and the study of these would seem to be inseparable from speculations as to the nature of the luminiferous ether, and from consideration of the conflicting theories as to its constitution. Formerly the vexed question was the mechanical explanation of an ether which should behave like an elastic solid a million times more rigid than steel, and at the same time as a mere vapor a billion times less dense than air. Then there was an outstanding quarrel between the followers of Fresnel and those of Neumann and McCullagh as to whether the vibrations of light were executed in or across the plane of polarization. Maxwell dissipated the controversy when on his electromagnetic theory of light he showed that both were present, the elastic vibrations taking place across the plane, and the magnetic ones in it. To-day, and ever since Maxwell propounded the electro-magnetic theory, the main interest has been transferred to the question how the ether is related to electricity and to ponderable matter, and whether the motion of matter in space affects or is affected by the ether. Is it a fact that the ether is stagnant, fixed, "while the molecules constituting the earth and all other material bodies flit through it without producing any flow in it"?[15] Or is the ether speeding along with the earth and the whole solar system in headlong and enormous flight? That singular doctrine, now in fashion, called "The Principle of Relativity," invites us first to deny that we can ever detect or measure the absolute velocity of the earth in space, and then to admit that therefore, since we cannot regard the ether as filling space or fixed in it, we must abolish the notion of the ether as a conveying medium, and must explain the finite velocity of light in some other way, depending on electro-magnetic principles inherent in the light impulse, and expressed in terms of co-ordinates whose origins are to be only relatively, and not absolutely fixed. Without pursuing these anarchical ideas, we may remark that for all useful purposes it suffices to admit that no terrestrial optical phenomena have any relation to the direction of the earth's motion through the universe.

As for the relation between matter and ether, while for clarity of thought we must frame some idea of the connection between them, we may accept Sir Joseph Larmor's dictum that "Matter may be, and likely is, a structure in the ether, but certain ether is not a structure made of matter." His view, that "the motion of matter does not affect the quiescent ether, except through the motion of the atomic electric charges carried along with it," is, of course, bound up with the further conception that the ether is a plenum in which "vortices or other singularities of motion and strain" are the nuclei of which matter consists.[16]

It was pointed out how in geometrical optics there is some advantage in stepping aside from physical considerations to deal with the geometrical laws in the abstract. So also in physical optics, there are mathematical laws governing the phenomena, the formulation of which in no way depends on the vexed questions of the ether or its connection with matter. A brave attempt has been made by Duhem[17] to perform this task. Confining himself to monochromatic light, and to isotropic media of perfect transparency, he has with rare and critical analytical skill built up a complete and general theory of optics, including interference, diffraction, and polarization, without making any assumptions as to the nature of light itself, except that it is a quality capable of transmission; so that physical optics become here a system of symbolic equations, the aim of which is to present rather than to explain the features, observable by experiment, in that quality.

But Duhem's *tour de force* was eighteen years ago, and the trend of physical optics at present is rather in the direction of pure experiment. Fraunhofer's invention of the diffraction grating is commemorated in our exhibition by a piece of his original apparatus, containing six gratings made by himself, a loan from the Royal Society. Of modern grating apparatus we have several examples: a photographic grating made by Lord Rayleigh in 1874, and some of those perfect reproductions in celluloid made by Mr. T. Thorp from Rowland's ruled gratings. Michelson (*Astr. Phys. Journal*, 1910) has succeeded in ruling gratings of a high degree of perfection, no less than 10 inches in diameter, from which great things are expected. A notable contribution to objects of this class is R. W. Wood's echelette grating, stamped, not ruled, with grooves of scalene section. We are further promised a study of diffraction patterns, by Mr. J. W. Gordon. Interference continues a subject of fruitful research. New forms of interferometer have been devised, for example, that of Fabry and Perot, and good work has been done by various workers with the échelon spectroscope of Michelson, and the interference plate apparatus of Lummer and Gehrcke. In the construction of such instruments the utmost precision is needed, and it may justly be stated that never before in the world's history has such marvelous optical workmanship been shown. Messrs. Adam Hilger & Co., who construct Michelson's échelons, have no easy task in fulfilling the requirement that each glass plate of which the échelon is built up shall be of the same thickness—usually about 1 centimeter—with an accuracy of one twentieth of a wave length. I have lately seen in Prof. Lummer's laboratory at Breslau a glass plate 15 centimeters in diameter and 4¼ centimeters thick, with faces guaranteed to be accurate all over to within one tenth of a wave length, and the accuracy attained over the central portion, within a diameter of 4 centimeters, was at least double as great; that is, there was no error of thickness so great as one part in two millions, or as if one had succeeded in measuring off a mile without an error greater than one three hundredth part of an inch.

Allusion was made already to Lord Rayleigh's fifth volume of "Scientific Papers." Time will not permit me to enumerate even the many important memoirs in physical optics to be found therein; but those on "Motion Through the Ether," on "The Spectrum of an Irregular Disturbance," on "The Passage of Waves Round Spherical Obstacles," on "The Origin of Prismatic Colors," on "The Measurements of Wave Lengths," on "The Dynamical Theory of Gratings," on "The Colors of Sea and Sky," proclaim him as our unquestionable master of to-day. Perhaps we live too near him to appreciate the permanent importance of his magnificent contributions to optics, of which these are the latest instalment.

Polarizing apparatus will be found in various forms in our exhibition, including sundry new large reflecting polariscopes, designed for and with the aid of my colleague, Prof. Coker, for the study of optical phenomena in strained transparent material. Brewster's discovery in 1815 of the optical effect of stress on glass led him to suggest that it might be applied to the useful and important object of ascertaining the state of strain or compression of the different parts of structures, such as bridges or framings, by the use of glass models. Prof. Coker, imbued with the same idea, has made models, in transparent celluloid, of many kinds of structures, from a crane-hook to the deck of a torpedo boat, and particularly of springs of different kinds, and has explored and measured the distribution of strains in them. To eliminate in such observations the "black cross" effect inevitable in the dark field of the polariscope, we have employed quarter wave plates of mica of large size. Some of these are 12 inches square. Others are circular up to 20 inches in diameter; others rectangular 40 inches by 10 inches. For these largest sizes it has been necessary to join together two pieces.

The properties of ultra-violet light, as well as those of the infra-red rays, have received much attention in recent years. No researches in this field are of greater intrinsic interest than those of Prof. Wood, whose shadowless mid-day photographs of natural scenes are truly surprising. Prof. Wood's book on "Physical Optics," now happily in its second edition, is a wonderful repertory of the whole round of phenomena in this domain. There could be no better antidote to the poison of "examinational optics," as found in the common textbooks, than the whole-hearted possession of the contents of this book.

Lastly, in this hasty survey of this branch, there is the vast subject of radiation by incandescent bodies. The law of Stefan, connecting the total amount of radiation with the absolute temperature, has been supplemented by the further relations discovered by Wien, Paschen, Lummer, and other investigators. Lummer's work on the radiation of the ideal black body, or, as we now call it, "full" radiation, is at last being properly recognized. It suggests much that still calls for further research.

SPECTACLE OPTICS.

It seems a far cry from "trunk spectacles," as our forefathers quaintly named their telescopes, to visual spectacles, but the oldest application of optics is undoubtedly that of aiding vision. The fixing of two lenses together to form a pair probably dates from the thirteenth century, but history is obscure. Raphael, in 1517, painted Pope Leo X wearing concave spectacles. But not all pictures are good as evidence, for there is, or was, in the Chiesa de' Ognissanti, in Florence, a picture attributed to Sandro Botticelli, depicting St. Jerome in his cell, with a pair of spectacles beside him. This does not prove that spectacles existed in the fourth century; and the presence of the spectacles may be as great an anachronism as in another picture of the same Saint is the presence, on the wall of the cell, of a pendulum clock. Coming down to the present day, few persons probably are aware of the rapid rate at which that branch of the subject is developing into a severe scientific study. Perhaps they think that the only progress in spectacle making has been the introduction of lighter spectacle frames or ingenious dodges for grinding bifocal glasses, or for fusing one kind of glass into another for a bifocal lens, or for grinding toric lenses. This would be quite a mistake. It may be that the teaching in the medical schools has remained much as it was; but the training of spectacle opticians to deal with the problems of astigmatism, both of eyes and of lenses, has taken great strides, and under the stimulus of the system of certification by the Spectacle Makers' Company and of other optical bodies, is assuming an important development. Improved instruments for retinoscopy and keratometry are in evidence, and the young opticians are very keen to be in the forefront.

But, apart from actual practice, an exceedingly important advance in theory has been initiated by the genius of Allvar Gullstrand. In the year 1908 he pointed out that the center of rotation of the eyeball does not coincide with the nodal point, which is its optical center. It is, in fact, from 2 millimeters to 3 millimeters behind it; and therefore in all those uses which the eye makes of its power of turning about in its socket, the mathematical treatment which assumes it to be fixed is inadequate. The assumptions of the Gauss system are no longer fulfilled, and modifications have been introduced. For precise work this affects the efficiency of spectacle lenses and introduces new sources of aberration. For this reason spectacles should be so designed that the particular point at which they are corrected for radial astigmatism should lie at the center of rotation of the eye. The importance of correcting this source of error is greater in the case of eyes whose refractive power differs greatly from the normal, and, in especial, for eyes that have been operated upon for cataract. The very thick lenses thereby necessitated, if ground with the usual spherical curves, are, as Gullstrand has shown, quite unsuitable for any oblique vision. He has shown that special forms are needed, and has devised aspherical lenses to meet that need. But while it would be difficult to over-rate the importance of this advance, care is needed

* Delivered June 19th, 1912.

[14] Herschel, in 1828, in his article "On Light" (Encyclop. Metrop.), page 450, declared "The fact is that neither the corpuscular nor the undulatory, or any other system which has yet been devised, will furnish that complete and satisfactory explanation of all the phenomena of light which is desirable. Certain admissions must be made at every step, as to modes of mechanical action, where we are in total ignorance of the acting forces; and we are called on, where reasoning fails us, occasionally for an exercise of faith."

[15] Larmor, "Æther and Matter," 1900, page 163.

[16] Particular reference may be made to Sir Joseph Larmor's "Æther and Matter" (1900) and to Prof. E. T. Whittaker's "History of the Theories of Æther and Electricity," 1910.

[17] "Fragments d'un Cours d'Optique," Bruxelles, 1894.

on the other hand, that no false impression is created. For all those optical purposes where the eye is fixed to gaze through an eye-piece, and not rolling about in free vision, the new theorems are of little importance. Gauss's system has not been overthrown. Collinear relations never did, in fact, apply strictly to the formation of images[13] in the eyeball, for the images there are not required to be focused (as in a camera) upon a flat plate, but are thrown on the interior surface of a globe. It does not appear that any mathematician has ever even considered the conditions necessary in an optical system, in which the curvature of the image is regarded as an advantageous result. Possibly some future calculator will discover how much better adapted to its own work the optical system of the eye is than if it had been designed to be free from the so-called aberration of curvature.

[13] The fact that the parallel lines of a wall opposite which one stands seem to bend toward one another on both sides has been known for 150 years.

One other point in spectacle optics needs attention. Thirty years or more have passed since British opticians ceased to denominate their lenses in terms of inches of focal length, and adopted the dioptric system of numbering, in which a lens having a focal length of 1 meter is described as having a power of one dioptrie, and a lens of twice that power as of two dioptries. The dioptrie, the international unit of lens power, was adopted in 1875, on the proposal of Monoyer, at the Brussels Conference. Nearly thirty years ago it was pointed out that the dioptrie, being the reciprocal of a length, is in reality a unit of curvature, and may be applied to express curvatures of wave fronts and of surfaces, as well as the power of a lens, which is, in fact, merely the expression of the convergency which it imposes on the light passing through it. For over twenty-five years, at the City Guilds Technical College, Finsbury, and for nearly twenty years at the Northampton Institute, geometrical optics has been taught on the dioptric or curvature method. But, strangely enough, the impression made in some quarters by Gullstrand's work is so great that the legend is growing up that he is the discoverer of the curvature method, and the framer of the dioptric system. Two recent German text books have lately been published, in which—implicitly in one, explicitly in the other—it appears that the method of numbering lenses in dioptries, instead of inches, is due to the famous Swedish ophthalmist. It may be, though it is scarcely credible, that the dioptric numbering of lenses was unknown in Germany until 1899.

The Manufacture of Lithopone*

An Economic and Hygienic Substitute for White Lead

By E. Lemaire

Lithopone is a white pigment, the employment of which as a substitute for white lead was proposed twenty years ago when the hygienists first began seriously to object to the use of white lead because of its poisonous character. Zinc white, which was also proposed as a substitute, has certain disadvantages which limit its employment. It costs more than white lead and has less covering power. It is true that a pound of good zinc oxide has in itself more covering power than a pound of white lead, but it requires to be applied in three or four coats instead of one or two and necessitates the use of more oil.

Lithopone is a mixture of two almost inalterable white pigments, barium sulphate and zinc sulphide and is made from cheap material, zinc wastes and heavy spar, so that its cost of production is barely a third of that of zinc white. It also covers better than zinc white, but it does not adhere so well, especially on iron, and is less resistant to the action of alkalies and the weather.

Lithopone is now employed extensively, especially in Germany and the United States. In Europe its production is almost confined to Germany and to German branch houses in other countries. A good deal of secrecy is observed in the manufacture; a fact which appears strange in view of the simplicity of the chemical actions involved, but which is justified, as we shall see, by the necessity of employing special machines in order to assure the cheapness and uniform quality of the product. For a long time, indeed, very few factories were able to produce a pure white pigment unaffected by light. The whole interest of the industry resides in the apparatus employed, which is little known in France, where the question is particularly important because the law of 1909, which prohibits the use of white lead, will go into operation on January 1st, 1915. Hence several French lithopone factories are improving their equipment and a number of makers of white lead are preparing to take up the manufacture of lithopone, which costs about half as much as white lead. Before describing the apparatus, we shall say a few words on the chemical composition of lithopone and the reactions by which it is produced.

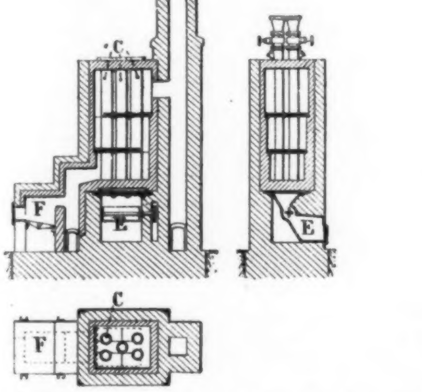


Fig. 2.—Vertical Retorts. *C*, Retorts; *E*, Extractor; *F*, Furnace.

The Raw Material.—When aqueous solutions of barium sulphide and zinc sulphate are mixed, a double decomposition takes place, resulting in the formation of two insoluble white compounds: barium sulphate and zinc sulphide, which are precipitated simultaneously. An intimate mixture of these two compounds which has been subjected to sundry operations constitutes the pigment lithopone. The proportions and purity of the constituents vary in different factories, and in different brands produced in the same factory. The quality of the lithopone depends largely upon the care exercised in the preparation of the two soluble salts, barium sulphide and zinc sulphate. These, salts therefore, are always prepared in the lithopone factory. Some German firms make a lithopone of the best quality, containing a large proportion of zinc sulphide, from which they obtain lower grades by admixtures of pulverized natural barium sulphate (heavy spar) which is very cheap, but which absorbs oil far less perfectly than the percipitated barium sulphate which is contained in genuine lithopone.

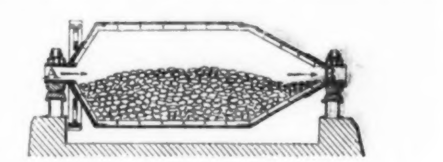


Fig. 1.—Hardinge Tube Mill.

The soluble barium sulphide is obtained by reducing heavy spar (natural barium sulphate) by charcoal at a red heat, and leaching the mass, after cooling with water. The heavy spar and charcoal, according to Nagel (*Zeitschrift fuer angew. Chemie.*) should be ground and mixed together in revolving tube mills, which can be cheaply operated. In the United States, the Hardinge tube mill (Fig. 1) is coming into use. The heavy spar and charcoal are introduced at the end *A* and the pulverized mixture passes out at the opposite end *B*. Although the apparatus contains no sieve, the conical form of the vessel and its rotary movement produce an automatic gradation, so that only a finely ground mixture escapes at *B*, while the coarser particles remain in the mill for additional grinding. The reduction is accomplished in reverberatory furnaces, retorts or muffles. The operation may be either intermittent or continuous. In the latter case, the usual one when a reverberatory furnace is used, the mixture is deposited near the front of the furnace and pushed back at regular intervals. Continuously operating groups of vertical retorts (Fig. 2), or intermittently operating muffle ovens (Fig. 3) are also employed. In both of these cases the losses which are occasioned by oxidation in the reverberatory furnace are avoided, but the consumption of fuel is greatly increased.

In the United States, where skilled workmen are rare and labor is dear, a revolving furnace like the Bruckner apparatus used in soda factories is employed. This furnace gives very good results, but its continuous rotation produces and disseminates dust, which must be removed by a collecting chamber placed between the furnace and the chimney. A furnace of this kind, 6 feet in diameter, 13 feet long, and making one complete revolution in two minutes, suffices for the production of 10 tons of lithopone per day. Nagel suggests the employment of the revolving furnace which is used for producing cement clinker and which operates continuously and consumes little fuel.

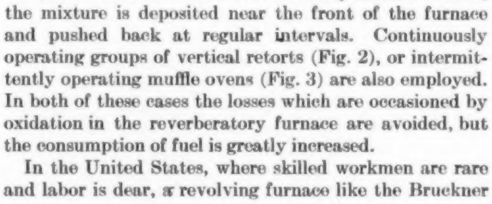


Fig. 4.—Gas-heated Muffle Ovens. *G*, Recuperator; *M*, Muffler; *P*, Gas Generator; *V*, Gas Valve; *V'* Air Valve.

The hot reduced mass is placed in iron cars, provided with sheet-iron covers in order to prevent oxidation of the barium sulphide to sulphate, and allowed to cool. The leaching is accomplished in double-bottomed vats or in the Shank apparatus employed for the leaching of crude soda in the Leblanc process. The operation must be conducted rapidly in order to prevent oxidation.

All that part of the factory which is devoted to the preparation of barium sulphide should be separate and distant from the rooms in which the manufacture of lithopone takes place, for the smallest trace of charcoal dust or natural barium sulphate would irremediably destroy the whiteness of the lithopone. Natural barium sulphate is often very impure and frequently contains salts of iron and other metals. A trace of iron salt in the barium sulphide makes the lithopone sensitive to the action of light. Such traces of impurity are removed by methods which have been kept secret.

In Germany the zinc sulphate employed is obtained from complex ores rich in zinc blende (natural zinc sulphide). These ores are roasted until the blende is converted into oxide and are then treated with sulphuric acid. In the United States, zinc white of inferior quality and natural oxides of zinc are used. It is also possible to employ zinc scraps dissolved in sulphuric acid. The crude solution of zinc sulphate is placed in a vat and mixed with granulated zinc or zinc scraps, which precipitate any copper and lead which may be present. The clear liquid is decanted and boiled with an admixture of chloride of lime, which oxidizes and precipitates the salts of iron and manganese as insoluble oxides. The mass is passed through a filter press and the clear liquid is collected in reservoirs.

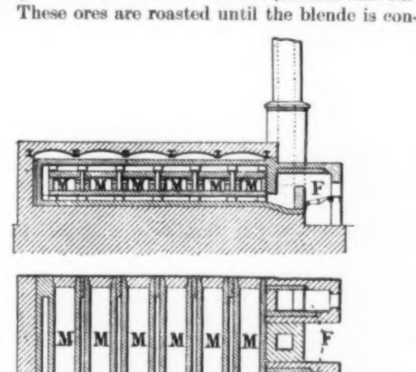


Fig. 3.—Muffle Ovens. *M*, Muffler; *F*, Furnace.

In order to produce lithopone the solutions of zinc sulphate and barium sulphide are mixed in the desired proportions in a precipitating vat. The mixture is heated by steam for some time and the precipitate formed is separated in the filter press and washed with water. The drying is effected continuously in drying tunnels provided with blowers and heated by steam. The precipitate is placed in layers on wooden shelves in cars, which are drawn through the tunnel.

The dry product is heated to a dull read in muffles. The ovens are heated with charcoal or now, preferably, by recuperating gas generators (Fig. 4). The hot hard mass resulting is quenched in cold water which causes it to crumble. It is again filtered out and dried, and is then pulverized and sifted. In general, the final grinding is applied to the moist product before the final drying, unless it is possible to employ dry grinding in a tube mill of the Hardinge type.

* From *Le Genie Civil*.

The Sixth Sense of the Bat

Sir Hiram Maxim's Contention. The Possible Prevention of Sea Collisions

To many of our readers the mention of a sixth sense and its application to the possible avoidance of collisions at sea will unquestionably appear very extraordinary. When, however, it is realized that such an announcement emanates from so distinguished a scientific authority as Sir Hiram Maxim, who, long before the late "Titanic" disaster, gave the matter much reflection, its revelation is likely soon to find numerous believers.

The Sixth Sense, as explained to the writer by Sir Hiram Maxim, is one possessed by different kinds of animals, who are enabled, through its agency, to detect objects in their vicinity without the aid of any of the usual five senses of seeing, hearing, feeling, tasting and smelling. This has been proved by very many experiments with animals, successively deprived of each of these five senses, who could nevertheless, at all times and under all conditions, detect the presence of others as well as clearly detect and avoid every obstacle in their vicinity and readily move about to procure the necessary food. The great Italian physiologist Lazaro Spallanzani (1729–1799) is said to have been the first to discover that, above all other animals, certain kinds of bats, more particularly, possessed a veritable sixth sense to an extraordinary degree. His investigations, which covered quite an extended period of time, showed conclusively that the particular kinds of bats that possessed this remarkable sixth sense were provided with extremely small eyes that could be of little or no use to them in the dark; furthermore, that all bats endowed with this sixth sense are very diminutive in size and consequently move their wings very rapidly while the large bats with comparatively slow-moving wings have large eyes and are not possessed of the sixth sense.

Since Spallanzani, several others have experimented with a view of ascertaining the manner in which bats are able thus to detect objects in their vicinity, but the French naturalist, Baron Cuvier (1769-1832), was the first really to appreciate the results of the then known experiments and he arrived at the conclusion, now generally accepted, that the wonderful power possessed by bats of directing their flight in places so dark as to render the sharpest eyes useless, was due to an exceptional development of the sense of touch, residing especially in the great delicate membranous expanse of the wings. These organs are really of the most delicate structure and are traversed by nerves, the fine ramifications of which terminate in little loops, like those found in those parts of the skin in man in which the sense of touch is manifested with the greatest perfection; and their surface is covered with rows of small thickened points, or papillæ, which may very probably have something to do with the perception of exceedingly delicate tactile impressions. In many cases, the organ that gives the bat this sixth sense is spread all over its face. In the vampire bat the organ is on the tip of the nose; it stands up in air and is called the "shield," but in most of the small bats that catch insects on the wing, we find two little leaves, not unlike the wings of the insect that it pursues, standing up just in front of its ears. Others have the sensitive spots located on other parts of the face, as will be seen by the accompanying illustrations:

Sir Hiram Maxim.

As we have seen, the bats that are provided with the so-called sixth sense are very small and it is probable they make about ten to twelve strokes with their wings in a second of time. This, of course, produces an extremely low note that does not appeal to our ears, but it travels after the manner of sound—or light, for that matter—strikes all the surrounding objects, becomes modified by their character and size and is reflected back, and these reflections or echoes are received by the organ of this sixth sense and are analyzed exactly as light waves would be by our eyes under similar conditions. It is, therefore, certain that the bat obtains its knowledge of surrounding objects by sending out certain atmospheric vibrations and receiving back, in a fraction of a second later, the reflected and modified vibrations.

Sir Hiram proposes to apply this sixth sense to seagoing vessels. He has constructed an apparatus that will produce atmospheric vibrations of about the same frequency as those produced by the bat, but, instead of using the infinitesimal amount of energy produced by the bat, he uses two or three hundred horse-power, that is, he sends out waves that have an amplitude and energy at least three hundred thousand times as great as those sent out by the bat. These vibrations, although of great energy, will not be audible to our ears, but they will shake up and agitate light objects for a considerable distance and will travel at least twenty miles, so that they could be received and recorded by a suitable apparatus at that distance, and would be able to travel at least five miles and send back to the ship a reflected echo that would be strong enough to be detected.

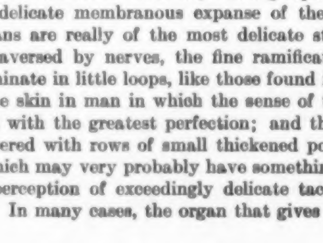
He employs three distinct devices: one for producing and sending out the necessary air-waves, another for receiving back the reflected waves and making them reveal their presence by ringing bells, and a third apparatus for recording the amplitude of the waves. To use his own words: "For producing the vibrations of waves, I prefer to employ a modified form of a siren, the disk being rotated at a suitable speed by a motor of some kind, preferably an electric motor. I prefer to use a very high pressure of steam and I have all the parts large and strong, to produce about fourteen or fifteen vibrations per second. These will not come within the range of the human ear and consequently cannot be considered as sound; as they are of great amplitude and power they are able to travel over great distances, and when they come in contact with a body, the waves are reflected back to the ship in the manner that sound would be reflected back, but this echo would not be audible to the human ear. I, therefore, provide an apparatus which might be considered an artificial ear. It is provided with a large diaphragm tightly drawn over a drum-shaped cylinder, and so arranged that the atmospheric pressure is always the same on both sides, quite irrespective of any air blast. It is, therefore, always able to vibrate freely in response to the waves of the echo, and its vibrations are made to open and close certain electrical circuits which ring a series of bells of various sizes. If, for example, the object is a very small one or at a very great distance from the ship, a very small bell rings, while a large object at a distance of two miles would ring a larger bell and a very large object a still larger bell. This apparatus gives an audible notice if anything is ahead of the ship.

"The other apparatus is similar, but, instead of ring-

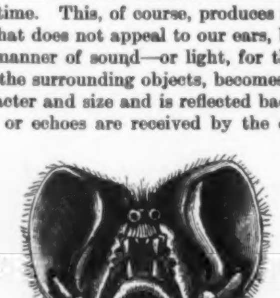
The Long-earned Bat Has Two Wing-like Leaves of Great Sensitiveness in Front of the Ears. The Ears Can Only Hear Rather High Notes, but the Two Little Leaves Vibrate in Unison With Very Low Notes, Much Lower Than the Human Ear is Able to Take in. This Bat Can Therefore Pursue and Capture Insects in the Dark Without Seeing Them.

The African Magaderm, Possessing Very Large Ears, and Also Provided With a Sensitive Organ Attached to the Nose. A Very Fierce Little Beast—in Fact, a Species of a Vampire, Feeding Not Only on Insects, But Killing and Devouring Other Bats.

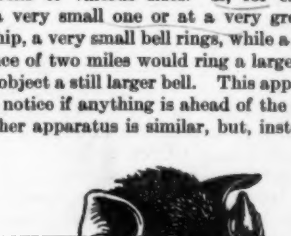
The Mourning Horseshoe Bat, With Very Small Eyes, has a Very Complicated Sensitive Organ Which Occupies Nearly the Whole of the Face.



Townsend's Bat, With Small Eyes, and With the Sensitive Organ in Front of the Ears as Well as in Two Egg-shaped Projections on the Nose.



Cestoni's Bat, Found in the Dark Passages of the Pyramids of Egypt, With Small Eyes and With the Sensitive Organ in the Ears and Also on the Upper Lip.



The Speckled Vampire Bat, With the Principal Organ Projecting From the Nose. It Will, However, be Noted That it Has the Rudiments of the Wing-like Leaf in Its Ear, Which Shows That Its Early Ancestors Belonged to the Kind of Bats That Possess This Leaf.

ing a bell it produces a diagram of the disturbances in the air, that is, when there is no noise except that due to the action of the ship or the sea-waves, a wavy line is produced, but wherever the vibrations sent out by the vibrator strike an object and return, the wavy line on the paper becomes very much increased in amplitude so as to be easily observed and the distance that the object is from the ship can be measured by the length of the paper strip between the giving off of the vibrations and the receiving of the echo; therefore, the distance can be determined with a considerable degree of nicety, and the size of the object may be determined by the amplitude of the waves that return.

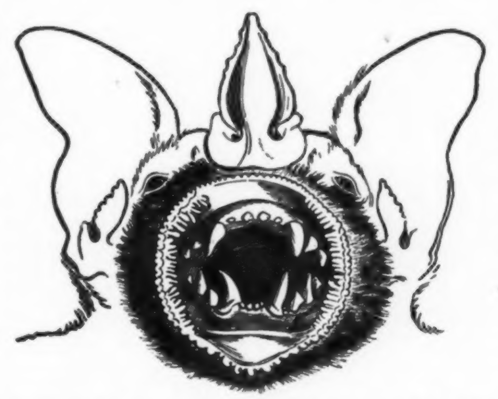
"The apparatus for producing the atmospheric vibrations should be placed well forward on the main deck, or in any other position where it can be turned about from port to starboard. It should be very firmly secured to the deck, and connected with a high-pressure boiler by three-inch pipe. A straightway valve should be placed in the pipe near the boiler, and means should be taken to prevent accumulation of water in the pipe leading to the apparatus.

"Of course, there would be no use for the apparatus except in dark, foggy or stormy weather, unless it was to be used for communicating with other vessels. When, however, the presence of other ships or of icebergs is suspected at night, the apparatus should be used constantly, sending out the blasts in every direction. If the sea were perfectly clear, the blasts sent out would be recorded at the very instant of their production, but no echo would be returned other than that due to the waves of the sea, which would produce a zig-zag line of small amplitude; but if there should happen to be an object of any considerable size at a distance no greater than two

The Trident Bat Has a Very Complicated Organ Which Covers Nearly the Whole of Its Face, and is Extremely Sensitive.

or three miles, the zig-zag line on the paper would be charged, the amplitude of the waves would be greater and would be very noticeable. To make sure the blasts could be repeated several times; if the result should be always the same, it would indicate the presence of some object, and the length of paper between the primary blast and the echo would indicate the distance that the object was from the ship. It might be so arranged that one inch of paper represented a mile.

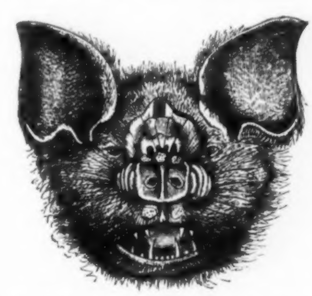
"To many it will appear doubtless very difficult, even on the verge of the impossible, to reveal the presence of objects at sea by simply sending out atmospheric vibrations and receiving the echo of the same. One might ask, how can it be possible to judge of the size, distance, and character of the object by the echo? If, however, we make a careful study of the matter, we shall find, if we send out a powerful blast of sound like a deep musical note, that it will travel a long distance, and if it strikes any object of considerable size, it will send back a reflec-



Mouth of the Spectacled Stenoderm, Showing Not Only That the Sensitive Organ is in the Ears and on the Nose, But That the Lips Themselves Are Sensitive.

tion or echo. Sound is nothing more or less than atmosperic vibrations. If there are less than sixteen vibrations in a second of time, they are not audible to our ears; we do not hear them, although we may feel them. They may be of great power and able to travel a long distance, and if they should happen to strike any object they send back an echo which, although completely inaudible to our ears, is sufficient to record itself by suitable apparatus, and the record thus made will give us a fair idea of the object struck. It will indicate the size and shape with a fair degree of accuracy; it will indicate its direction from the ship and will also show its distance with great accuracy. It will distinguish a ship from an iceberg, will show whether the object is stationary or moving, and, if moving, the direction and velocity of such movement."

"Suppose," says Sir Hiram, "that our ship is making twenty miles per hour and we find, upon sending out several blasts, that the echo reaches us in twenty seconds, we infer that, as it took ten seconds for our vibrations to reach the object and another ten seconds for the reflected vibrations to return, the distance is slightly over two miles. Our ship is doing twenty miles per hour, and one minute later we send out another blast, but the result is no stronger than before, so we change the direction of the blast and find that the greatest effect is produced when the blast is sent out dead ahead, also that the distance between the object and our ship is being reduced at the rate of thirty-five miles per hour; therefore, the unknown object is evidently a ship making fifteen miles per hour and travelling toward us slightly to our starboard. Our next blast shows us that the ship is only a mile distant, and very much to the starboard; we follow her direction and when she is in a position to present her broadside to us, we find on sending out a blast that the echo is very strong, the bells at the receiver ring violently and the recorder makes a large and distinct marking on the paper strip. The weather has been so thick that we have not seen the ship, but we have a fair idea of her; we know her speed and the direction in which she is sailing. Later on, we receive a series of records from each blast, showing that there are several small objects in our vicinity, probably fishing boats. We are able to locate them and measure their distance, and, if any of them are dead ahead of us, we change our direction so as to give them a wide berth. Subsequently, we have a new experience; we send out a blast and receive back an echo showing that there is an exceptionally large object very nearly dead ahead of us. We know it is large because the distance indicated is ten miles and the record quite distinct. By sending our repeated blasts, we find that the distance between us and the object diminishes about one third of a mile in a minute. This, of course, is due to our own speed and indicates that the object is stationary. When we are two miles apart, the reflection of our blasts rings the bells and the indicator shows a different record from what we have seen before. The markings on the paper strip are of considerable size and commence sharp and abrupt, but the ending is not sharp or distinct. There is a trailing out of spots made by the zig-zag lines. The total length of the echo is thus made larger than that produced by the primary blast. This shows that there is some kind of a cloud about the object of a different density from the surrounding air and that it is of considerable size. Therefore, we draw a logical conclusion. The object is of great size; it is stationary and it has something about it that modifies the echo; consequently, the record on the paper strip resembles that obtained from both a large, solid object and a cloud. Therefore, it must be a large iceberg surrounded by cold air. We change our direction so as to pass it on our port side at a distance of half a mile. Fortunately we have barely passed when the fog lifts and discloses an enormous iceberg surrounded by smaller pieces of ice that have been broken off. At another



The Diadem Bat Has Small Eyes and its Leaf is Attached to Its Nose; It Has Also a Little Sac Which Secrets a Wax-like Substance Similar to Ear-wax.

time, we send out many blasts to port and starboard, and also dead ahead, we have a very slight indication that there is some large object ten miles distant and very nearly in the direction we are going. We expect to get a stronger reading in a few minutes but fail to do so. However, we keep on sending our blasts and at the end of an hour the readings are more distinct and the distance is reduced from ten miles to seven, showing that the object in question is evidently a ship going in the same direction as ourselves but at a lower speed. We come up to her and pass her in a short time; we next find that there is a very large object off our starboard beam. Our recorder shows the distance to be over twelve miles, and still the markings are quite distinct. What can it be? Reason tells us that it is a big liner with her immensely large broadside in a position to send back to us an echo such

Head of Brainville's Bat, Which Shows the Highest Development of the Organ of the Sixth Sense to be Found Anywhere in Animated Nature. The Whole Face, Including the Ears, is Covered With This Organ; the Nose, Ears and Chin, Are All Occupied and Covered with Sensitive Hairs. The Eyes Are Small and of Very Little Use.

Welwitsch's Bat. This Bat Furnishes Us With a Very Good Illustration of the Sensitive Wing That Enables a Bat to Send Out Vibrations and to Receive the Echo. The Spots on the Wing Probably Represent Nerve Centers.

as we have never received before at such a distance. We continue to send out blasts and soon find that the big ship is going in the same direction as ourselves and at a speed of fully three miles an hour faster than our own ship is travelling. In a short time she is so far ahead of us that we cannot receive back an echo. Again, on a very dark and foggy night, say, we are approaching the rugged coast of Ireland. We work our vibrator constantly, sending out strong blasts every four seconds, but we receive no response until near morning. We know that there is no danger, as our apparatus shows that the coast is clear, so we keep on full speed until we receive some response to our blasts. The first is very feeble and comes from a distance; twenty minutes later the record is strong and distinct, and there is more than one record. Some objects are only three miles distant and of no great size, while others are indicated fully ten miles distant, and from the size and shape of the records must be of great size. It proves to be the uneven coast of Ireland with mountains in the background. The fog continues dense; still, with our appliances we are able to skirt the coast, keeping our distance from the shore, and have no difficulty of feeling our way into port."

The accompanying illustrations fully explain the apparatus made use of by Sir Hiram Maxim:

Fig. No. 1 represents a vertical central section of the apparatus for producing the vibrations. The rotating disk is driven at a uniform speed by an electric motor, so that the pitch of the note sounded is always the same. The steam enters the central pivot, passes through the balanced valve, and escapes through expanding nozzles into the small end of the trumpet. The balanced valve is opened and closed by means of a handle, as will be seen; the opening and closing of the valve also makes and breaks electric circuits.

Fig. No. 2 shows a side elevation of the complete apparatus on a greatly reduced scale. The trumpet, being of great size, is supported by a wheel and may be turned in any direction without interfering with the supply of steam, which enters through the center of the pivot on which the apparatus revolves. It is proposed to use this form for long-distance work, but where it is desirable to spread the vibrations out and to occupy more territory, a much shorter trumpet is employed, which is bell-mouthed and does not require any support other than the central pivot.

The apparatus for converting the inaudible waves of the echo into sounds which are audible to the human ear is provided with a thin, tightly drawn diaphragm. The atmospheric vibrations cause this diaphragm to vibrate after the manner of the head of a drum, and in moving it opens and closes electrical circuits and causes bells of various sizes to ring. Any degree of fine adjustment may be made by means of the spindle, which is provided with a screw thread passing through a support inside of the cylinder. Whatever pressure of air there may be on the front of the diaphragm produces a similar pressure inside of the cylinder.

In Fig. No. 3 we have a vertical central section of the apparatus for recording the frequency and the amplitude of the atmospheric vibrations that strike the diaphragm. A very small and light rod is attached to the center of the diaphragm which passes to the rear and carries a pencil point that records the vibrations on a strip of paper similar to that used in a Morse instrument. When the operator moves the handle of the siren downward, he not only opens the steam valve, but closes an electric circuit which releases the mechanism of the Morse instrument and allows about fourteen inches of the paper to be fed out.

The primary blast sent out by the siren is registered on the paper strip, and the distance that the object is from the ship may be determined by the distance between the record of the primary blast and the echo received, as shown in the drawing. Observe the markings on the strips of paper shown at the top of the drawing.

Fig. No. 4.—Some engineers might imagine that it would be very difficult to mount these delicate instruments on a vibrating ship so as not to interfere with their fine adjustment and accurate working, but this trouble is overcome by mounting them as shown in Fig. 4. They are placed inside of a large hoop and suspended by eight pure rubber straps. This effectually prevents them from participating in any of the vibrations that are peculiar to a high-powered ship.

Prof. John Tyndall, "the poet of science," instructed by the British Government to conduct experiments for ascertaining the best means of preventing vessels running ashore in a fog, tells us not only that the reflection of sound from a solid body like a ship is very great, but also that he got astonishing results from acoustic and invisible clouds:

"On the 17th of October, at about 5 P. M., the air being perfectly free from cloud, we rowed toward the Foreland, landed, and passed over the seaweed to the base of the cliff. As I rached the base the position of the 'Galatea' was such that an echo of astonishing intensity was *sent back from her side*; it came as if from an independent source of sound established on board of

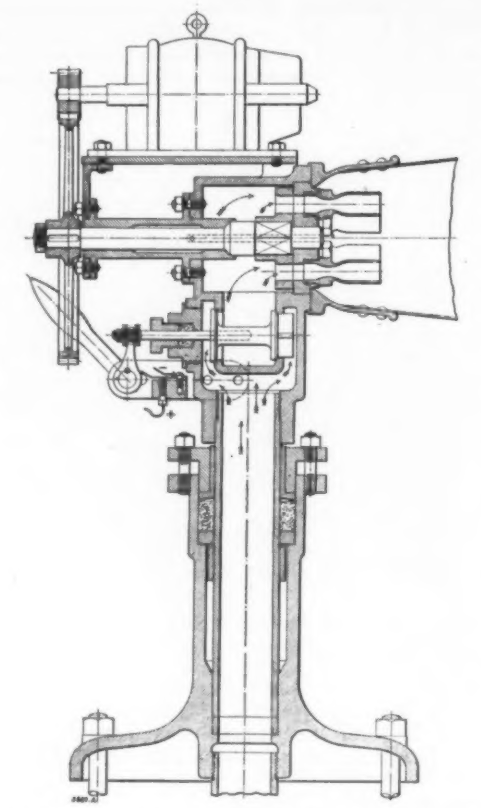


Fig. 1.—Vertical Central Section of the Apparatus for Producing the Vibrations.

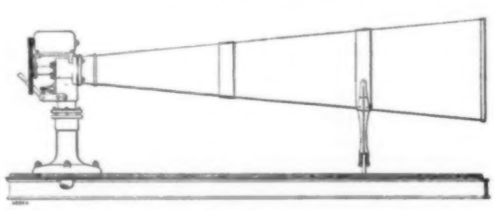


Fig. 2.—Side Elevation of the Siren or Vibrator.

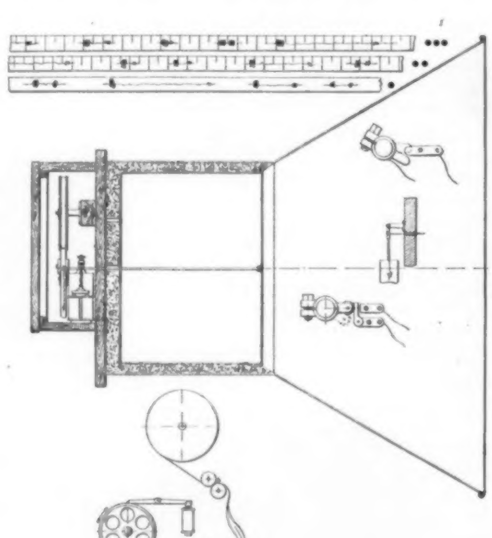


Fig. 3.—Receiver for Recording the Vibrations.

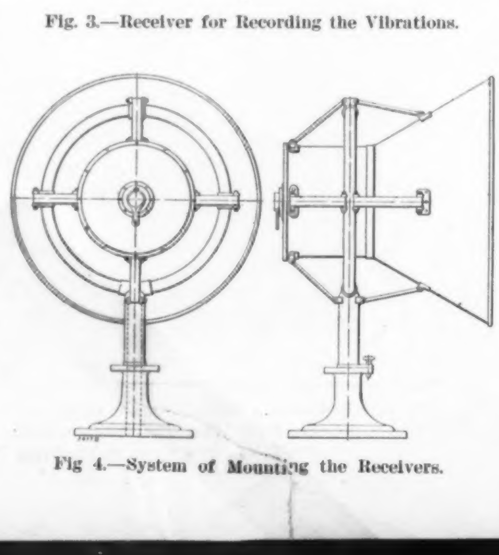


Fig 4.—System of Mounting the Receivers.

the steamer. This ceased suddenly, leaving the aerial echoes to die away gradually in silence."

On some occasions the learned professor was greatly puzzled. Sometimes, at a distance of three miles, he was quite unable to hear the report of the guns or the sound of the whistles or sirens, while on other days these could be heard at a distance of nine or ten miles. On one occasion they drew up as near as two and a half miles to the shore and still the sounds were inaudible. Suddenly a cloud obscured the sun, a dark shadow overspread the sea; then every instrument was heard, and, while the cloud was still obscuring the sun, they withdrew to a distance of six miles and practically all the instruments were heard.

It is a curious and interesting fact, says Sir Hiram, that anything in the nature of a light does best in perfectly clear weather, while anything in the nature of a sound does best in thick or foggy weather. Acoustic clouds that bar the passage of sound never exist in foggy weather; these clouds are produced by numerous conflicting currents of air at different densities caused by the interchange of the hot air from below with the cold air from above, and this action never takes place in thick weather; therefore, acoustic clouds cannot interfere with the working of his apparatus.

The siren furnished to Prof. Tyndall by the United States Government had a rotating disk 5 inches in diameter. The trumpet was 16 feet long, and the mouth measured 26 inches in diameter. It used steam at 70 pounds pressure to the square inch, and gave off an audible note. The probabilities are that when the steam valve was wide open the power represented would not be more than 50 horse-power.

On our large steamships, we very often have a boiler pressure of 280 pounds to the square inch. Suppose, now, that we use a rotating disk 10 inches in diameter and a trumpet correspondingly large, we can convert 500 horse-power into sound, sending out vibrations of enormous energy and amplitude, which ought to travel over distance very much greater than would be possible with any of the instruments employed by Prof. Tyndall. As the steam valve of a siren is only open for about a second at a time, it is very evident that the total amount of steam consumed would not be very great, although the energy when it was actually escaping might be 500 horse-power.

Attention to Passengers

In a series of circular letters to its employees the management of the Chicago Great Western Railroad has of late been preaching some good philosophy. In a recent letter addressed to train employees, dispatchers and station agents, under the caption "First Aid to Anxious Passengers," some pertinent questions bearing on the duties of train employees and station agents toward passengers are discussed, and some good advice is given these servants of the company as to the importance of maintaining the peace of mind of travelers while occupying the company's trains or while waiting at the stations. It is pointed out that such a thing accomplished brings larger returns to the company than fine equipment or any other modern improvements which can be advertised. We once heard a roadmaster eloquently express a similar idea in saying that "The finish of coaches and the flight of trains are not all there is to railroading."

In the circular referred to the management states: "We want it said of our road that our passengers are treated as our guests and that we do not lose interest in them as soon as their money drops into our till;" and, again, "We believe that a satisfied passenger is one of the best advertisements a railroad company can have." The circular then goes on to explain that the handling of the people who pay the bills is really the most important part of the employee's business, and attention is invited to the fact that the travelers in the smoking car and coaches, as well as those who ride in the parlor cars, help to "pay the bills." They should not, therefore, receive any less attention in matters which make for peace of mind, than those who pay for the luxuries of travel. Emphasis is placed upon civility of manner in answering questions, such, for instance, as the probable time when delayed trains will reach destination or connecting points, etc. Station agents are directed to call upon dispatchers for particulars as to the movements of delayed trains, and dispatchers are directed to co-operate cheerfully with station agents in regard to such information. Conductors are then requested to give such information to their passengers as accurately as possible, and in a manner which they can readily understand, bearing in mind that all passengers may not be familiar with the technical language of men in railroad service.

All this is mighty good doctrine for railroad men to bear in mind. There is a class of men, commonly known as gentlemen, who, whether serving as railroad conductors, station agents or in other positions, are always careful and considerate in their answers to the thousand and one questions asked of them, including

the unusual situations, such as when trains are delayed, as well as when everything is working to regularity. Not every well disposed person, however, is so blessed with equanimity that he does not become irritated or annoyed at some of the questions which people unaccustomed to popular ways can ask. Such is, therefore, the purpose of a circular of this kind—to caution employees against hasty replies to questions, even when such may seem to have little or no bearing on the business in hand. Station agents, conductors and other employees cannot be mind readers, and it is a good plan to give a direct reply to questions asked by the company's patrons unless the nature of the information desired should obviously suggest otherwise.

An important thing to bear in mind in answering questions is the manner of the reply. It, of course, gives offense to reply in a way that will unnecessarily show up the ignorance of the inquirer of the methods or practice concerning the thing he is asking about. Another thing about the manner of replying to questions, and in transacting business generally, is that agents or employees of the company should appear to take an interest in the welfare of the person who makes the inquiry. The "don't care" style of conversation is, at least, discouraging to the earnest seeker after information; and the employee who conveys the impression that if the passenger or other patron does not wish to do as the regulations require he can go and do the other thing, will not make friends for his company. Sometimes a simple explanation volunteered will suffice to clarify matters exceedingly, and a soft answer on the part of a railroad employee, even to a patron, who may seem to be of the refractory kind, may chance to turn away wrath as effectively as when uttered in some other situation.

The advice in this circular about giving attention to the needs of travelers in the coaches equal to those of persons in the parlor and sleeping cars is not far fetched. In this connection it should be borne in mind that many or all of the passengers who ride in the coaches may have paid first-class fare, and they are entitled to the ordinary conveniences and comforts. Such cars should be kept reasonably clean, and this can usually be done by sweeping out at terminals, where considerable stops are made, or by porters, if there is not sufficient time for this during stops; or by taking aboard a man with a broom, as is sometimes done.

Another convenience which is very often neglected is the lavatory. All modern coaches have wash basins, for the benefit of travelers who may desire to clean up as they approach their journey's end, or after a night's ride, but frequently one will find the pump out of order, so that he is unable to obtain water. Such an experience is aggravating, and in the sleeping cars would not be tolerated. Water, wherewith to remove the stains of travel, is but an ordinary convenience, and it is inexcusable that the passengers in the coaches should suffer neglect in this respect.—*Railway and Engineering Review.*

Combating the Dangers of Tropical Climates

The Resistant Powers of Temperate Races Not Equal to Acclimatization

By Dr. Robert Grimshaw

Since the history of the world has been written in detail, it is well known that for the dweller in temperate climates, and even for those who are born in the tropical zones, the climate of the latter regions is not merely difficult to withstand, but in fact dangerous. There are those of the middle latitudes who are benefitted by a short stay under the warm Southern sun, but in the end the climate is found depressing; and when it comes to the tropics themselves, the white man at least finds them unhealthful. Even if long continued sojourn therein does not cause absolute sickness (I use the word in the sense in which it is employed in the Bible and in Shakespeare, remarking that no officer calls for "*ill*" leave, but for "sick" leave) there is a certain lassitude and depression, which seems inseparable from the climate as such.

The resistant powers of the Anglo-Saxon race to climatic influences in particular are famed in story, and are written on the pages of the history of every colony which has been founded by them; but for all that the truth remains: that even generations fail to do away with the fact that the tropics have an unfavorable influence upon health and long life for the white man.

For this reason, sub-tropical climates have always been preferred as the seat of colonies to be founded; and where lower latitudes are chosen, only districts have been voluntarily selected which lie high above the sea. It is not merely a question of lassitude and discomfort; the matter is one of absolute danger. Neustätter, in discussing this subject in "Die Woche" says that the negro will stand a polar climate better than the white man will endure the hot damp atmosphere of the tropics. While this has hardly been shown, owing to the lack of negro settlers, or even travelers, in the very high latitudes, the fact remains that the English, Dutch and French governments have found that tropical climates cause a high percentage of mortality among their soldiers. This is, of course, in part due to the fact that in such climates the soldiers, as well as the colonists (and in this particular the Englishman is the worst of the three) habits of eating and drinking suitable to their native climate are kept up: for instance eating plum pudding on Christmas Day when it comes in mid-summer, and drinking brandy and soda even in Aden, the hottest place on the face of the globe. Further, the life led under such conditions is apt to be more irregular (to put it mildly) than at home.

Not only is the mortality of foreign white soldiers higher in the tropics than at home, but it is greater than that of the negro soldier. Neustätter puts it for the English troops at 4 to 1. The death-rate of the French soldiers at home in 1883-1884 was only 0.7 per cent; in Algiers and Tunis 1.1; in Cochin China 9.2; in Senegambia 52.7. This mortality extends to the children of the soldiers; so that in their case immorality and hard drinking can not be said to be predominant causes. In India it was 70 per cent as against only 22 in London; so that a British major stated that no regiment could raise enough children to replace its dead drummers and fifers. A stalwart and "steady" Irish cousin of the writer stated that six months' sojourn in Burmah had aged him ten years; and that there was not money enough in London to keep him in that hot climate any longer.

There must be a reason for these facts and figures. Of course, every one knows that certain infectious diseases belong only to the tropics; and that others are much more frequent and dangerous there than in the temperate zones; and it has been assumed by some that if they could be done away with, the heat alone, as such, could be combated, and the colonies rendered suitable for the inhabitants of the temperate zones. Commissions have been sent out to study the "sleeping sickness," the yellow fever, the cholera, the typhus, "beriberi" malaria, diarrhœa, inflammation of the liver, the bubonic plague, etc. Learned men have discovered the causes, and proposed means of combating them; but up to date in vain.

The following table, referring to the Dutch East Indies, although made up from figures for the year 1898, is typical. It gives the number of whites and of natives per 1,000 who were attacked by, and who died of, the respective diseases named:

	Whites.		Natives.	
	Attacked.	Died.	Attacked.	Died.
Malaria	748	15	362	3.6
Diarrhœa	107	23	25	3.8
Cholera	62	32	23.5	8.3

These figures have been reduced; but there remains the fact that acclimatization has not been accomplished.

Even where there is no absolute sickness, there is always tropical anemia, which makes the colonist or soldier unfit for active work or thought, although he may appear sound and healthy enough. This seems to be the real reason why the European succumbs more readily to the diseases already there. His system is weakened before he is attacked; he has lost his powers of resistance. The principal source of trouble, says Neustätter, is the heart; there is a quickening of the pulse and lowering of the force of the heart-beat; the heart is more excitable, and often enlarged. Breathing is more rapid, the temperature of the body readily increased, and there is a tendency to congestion of the blood in the internal organs, and especially in the liver, which enlarges; and that leads one to think that it must produce more gall in the tropics, or act as a substitute for or assistant to the lungs. The muscles, not only the voluntary but also the involuntary, as those of the heart, intestines, etc., become weak and flabby. This, of course, reduces the capacity for work; the skin becomes yellow and pale, which is said to be a sure sign of tropical anemia, but without reason, as there is no proof of diminished coloring matter in the blood. The nervous system is attacked, sleeplessness, liability to mental depression, nervous irritability, intellectual weakness, loss of memory, etc., show themselves. Every mental work calls for special exertion of the whole. The digestive organs show a disordered condition, and there are especially present, loss of appetite, and bad digestion.

These symptoms belong to the tropics, as such, and not to any one disease. Malaria has been blamed for this. The system is said to be impregnated therewith, but the fact that return to temperate climes produces betterment as an argument against this. Every one has been in doubt as to the real cause of these troubles.

Recently, however, Dr. Karl Ranke has thrown considerable light upon the subject. During his sojourn in Brazil he studied his own system; one of the first things that he noticed was a gradually increasing hungry feeling. This is strange, because in the tropics one eats and yet feels hungry. Now the hunger is readily explained. The heat causes an increase of temperature in the body, which can even cause "sun stroke" or "heat stroke." The human body can accustom itself to temperatures colder or warmer than normal, especially the former, because more clothes can be worn; but when it comes to great heat, that is different. The human body produces automatically heat enough to keep itself at about 36 deg. Cent., say, 98 deg. Fahr. (some say that the temperature of women is a trifle higher than that of men; others deny it). Against extra heat from without there seems to be no protection, but as an increase of temperature in the human body of 6 deg. Cent. or 10 deg. Fahr. or so produces death with absolute certainty, one sees the difficulty at once. The reduction of temperature of the body is accomplished by the evaporation of ordinary perspiration, this removing about 70 per cent of the heat produced. Where the surrounding air is dry and in motion, sweating can take place freely; where, however, the air is already saturated with moisture and is motionless, this is not the case. At 25 deg. Cent.=77 deg. Fahr. the air can contain 70 per cent of moisture; such temperature then is hard to stand, when combined with 82 per cent of moisture it is dangerous, and 28 deg. Cent.=82.4 deg. Fahr. with 84 per cent of moisture cannot be borne a long time by Europeans. In this particular the black races have the advantage over the white, because they perspire more freely, giving out about 5 per cent more heat by this means than white people do.

Naturally, when one is cold, one seeks to increase the warmth generated in the system, by rapid movement; the muscles alone being capable of producing nearly one third of the total heat of the body. Where there is too much heat, one naturally avoids such movement. But there remains the other two thirds, generated by the lungs, heart, kidneys and liver, and by general alteration of substance in the system. Even the production of the sweat as a result of the action of the nerves, glands and general circulation, is a source of heat.

The moral of this seems evident: one should eat less. But here instinct is deceiving; it goes too far. As far as generating heat is concerned, the body could get along with less food; but it must be kept in constant weight and strength, and this calls for nourishment. If one eats as little as the diminished appetite calls for, in the hope of lowering the internal heat, one gets hungry; whereas if one takes enough food to keep up the system there is at once production of heat. The result is a hungry condition, which results in damage to all the internal organs.

It is here seen that living in the tropics produces in the white race, even without any illness, an abnormal condition. There are, of course, very healthy persons who can get along in the tropics with a furlough every year, or even every two years, but all show diminished capacity for work.

Ranke, in looking into this subject, wonders why we know enough to heat our rooms in cold weather to keep our temperature right, have not sufficient logic to cool them artificially in hot climates. In the present advanced condition of the production of artificial cold by machinery, this should be neither difficult nor very costly. It would also reduce the amount of moisture that the air can contain; so that the same process would lessen both of the dangerous elements: warmth, and moisture.

Mineral Oil for Clockmakers.—The mineral oil used by clockmakers is heavy tar oil, purified by a peculiar process. To 100 parts of ordinary heavy tar oil, 2 parts of chloride of lime are added and stirred thoroughly into the oil, then 3 parts of crude hydrochloric acid are added. After the addition of the acid, the mixture must be very vigorously stirred and left standing for 6 hours. At the expiration of this time, the oil is poured off from the watery fluid and repeatedly shaken up, each time with 5 parts of caustic soda lye. Finally, the purified oil is filtered through gray blotting paper.

Making a Snow Measurement at a Height of 8,000 Feet.

The Conservation of Snow

Its Dependence on Forests and Mountains

By J. E. Church, Jr., Mount Rose Observatory, Nevada

Weighing Up a Snow Sample. The Depth Here is 15 Feet.

Some six years ago while engaged in meteorological studies on Mount Rose in the Sierra Nevada, the writer became actively interested in the problem of the relation of forests and mountains to the conservation of snow.

On that wind-swept peak there was evidence everywhere in profusion of the effectiveness of timber in anchoring the snow on the levels where it fell. Cliffs, lee slopes, and gullies played their part equally in retaining the snow, but wherever timber occurred the general result was accentuated. Indeed, all kinds of forest cover were beneficial, but the benefit afforded by each was in proportion to the height of the barrier it interposed to the wind. On the other hand, the slopes fully exposed to the wind were swept bare of their snow continuously, a fact that made the ascent of the mountain in winter comparatively easy.

In summer the snow lay in the same relative position as during the winter. The lee slopes bore the bulk of the snow, but wherever timber was found there the store of snow was relatively greater. *However, the greatest depth of snow in the forests did not occur under the individual trees but in the open in their lee*, an observation that has apparently convinced some observers of the worthlessness of forests for the conservation of snow. This phenomenon, due in the present instance to obstruction of wind currents, will be referred to again.

Photographic evidence of this close relationship between forests and the conservation of snow was obtained in abundance, but the necessity of reducing this evidence to definite figures impelled the writer to design a snow sampler capable of determining the moisture content of snow under all conditions of depth and density. The attainment of this object was facilitated by the Nevada Agricultural Experiment Station, which, with the generous consent of the Office of Experiment Stations, made the relation of forests to the conservation of snow a project under the Adams Act and gave it adequate financial support.

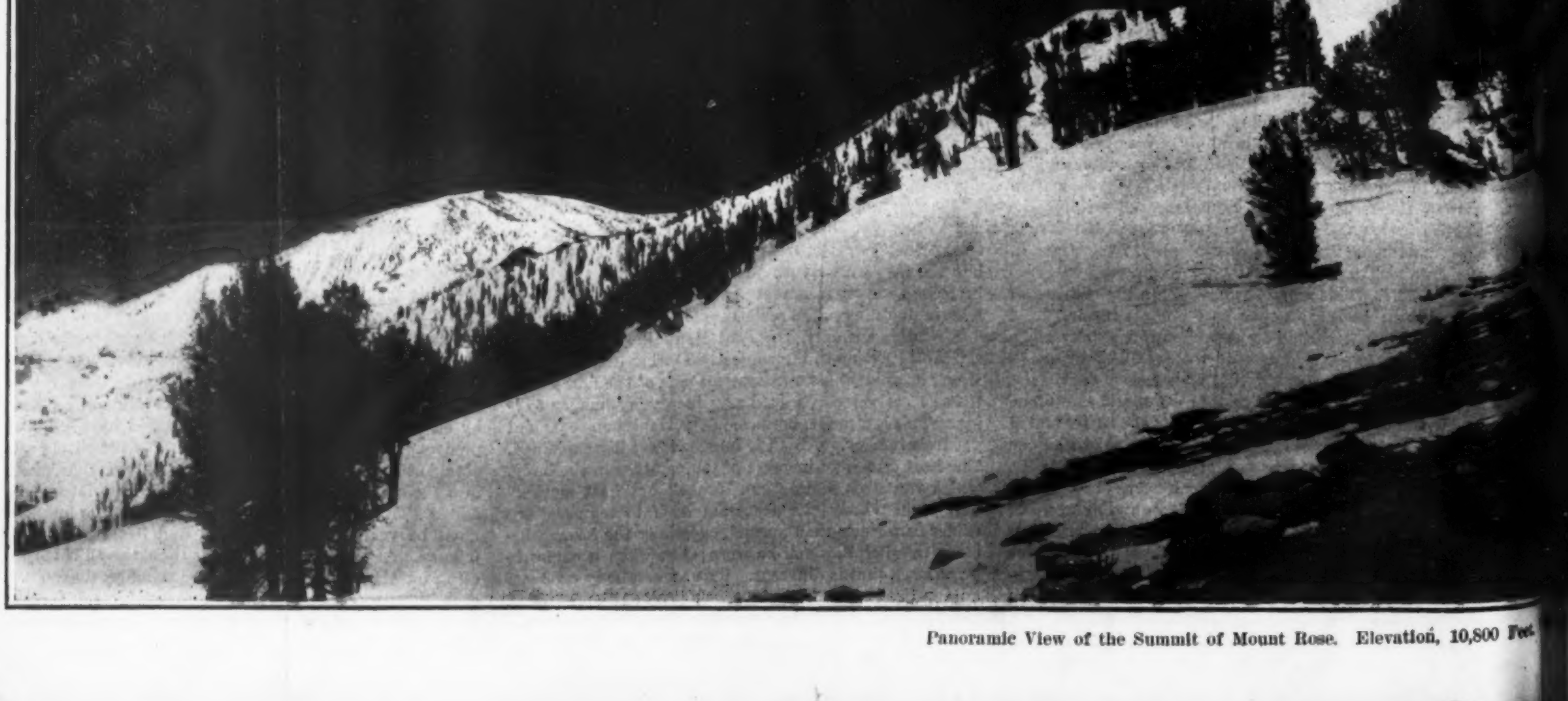
After prolonged experimenting and testing in the field during the winter of 1908-09, a snow sampler and weigher was perfected as follows:

The sampler (Fig. 1 diagram) consists of one or more sections of cold-drawn seamless steel tubing, containing at the lower end a special cutter designed to cut a core from the snow and open at the upper end to permit the exit of the core, when the weighing has been completed. Guide couplings fitted with threads are employed between the sections of the sampler to expedite the operation of coupling and yet assure a rigid connection.

By means of a series of slots (*C*) arranged alternately on opposite sides of the sampler the operator can readily determine whether the core is rising properly and thus detect clogging in the cutter or openings beneath the snow. Also by means of these slots, a pick (Fig. 8) can be inserted into the tube to break up any pieces of the core that may become clogged within the sampler. A scale of inches stamped on the tube indicates the depth of the snow.

The cutter (Fig. 2), whose orifice is smaller than the tube of the sampler, is constructed in the form of a tubular chisel, bevelled on its outer edge and (with the exception of a narrow vertical inner edge at the orifice) slightly tapers to an increasing diameter within. The upper edge of the cutter forms a narrow shoulder bench within the sampler tube and aids in preventing the core of snow from sliding down through the cutter when the sampler is drawn up. The tapering of the cutter reduces to a minimum the clogging of the snow or its freezing to the surface of the metal, while the still larger diameter of the sampler tube allows the core to rise without appreciable friction or clogging even in the deepest snow.

The chisel edge has been found fully adequate for



Panoramic View of the Summit of Mount Rose. Elevation, 10,800 Feet.

Sampling Snow Fifteen Feet Deep. Note the Strength of the Apparatus.

A Forest Glade. Nature's Opportunity for Storing Up Snow Against the Summer.

This Photograph Shows the Solid Core of Snow as it Comes Out of the Sampling Tube.

cutting all kinds of snow and has readily penetrated strata of blue ice at least one inch thick. The chisel edge also can be readily sharpened when blunted (as it frequently is) upon hidden rocks. For this reason a serrated cutting edge, which was designed, was never employed. In case the cutting edge becomes badly damaged or worn, another cutter can be readily inserted. The most feasible method of uniting the cutter to the sampler tube is by soldering; threads are not substantial enough because of thinness of the wall of the tube.

The external diameter of the sampler is about two inches, a size that adapts the sampler to being readily grasped in the hand and brings its weight within the limits of human strength even in deep driving. The gage of the metal is from 18 to 24, according to the length of the sampler, the greater thickness being employed for longer instruments.

The diameter of the cutter is carefully maintained at one and one half inches; and the computing of the water content is based on this standard.

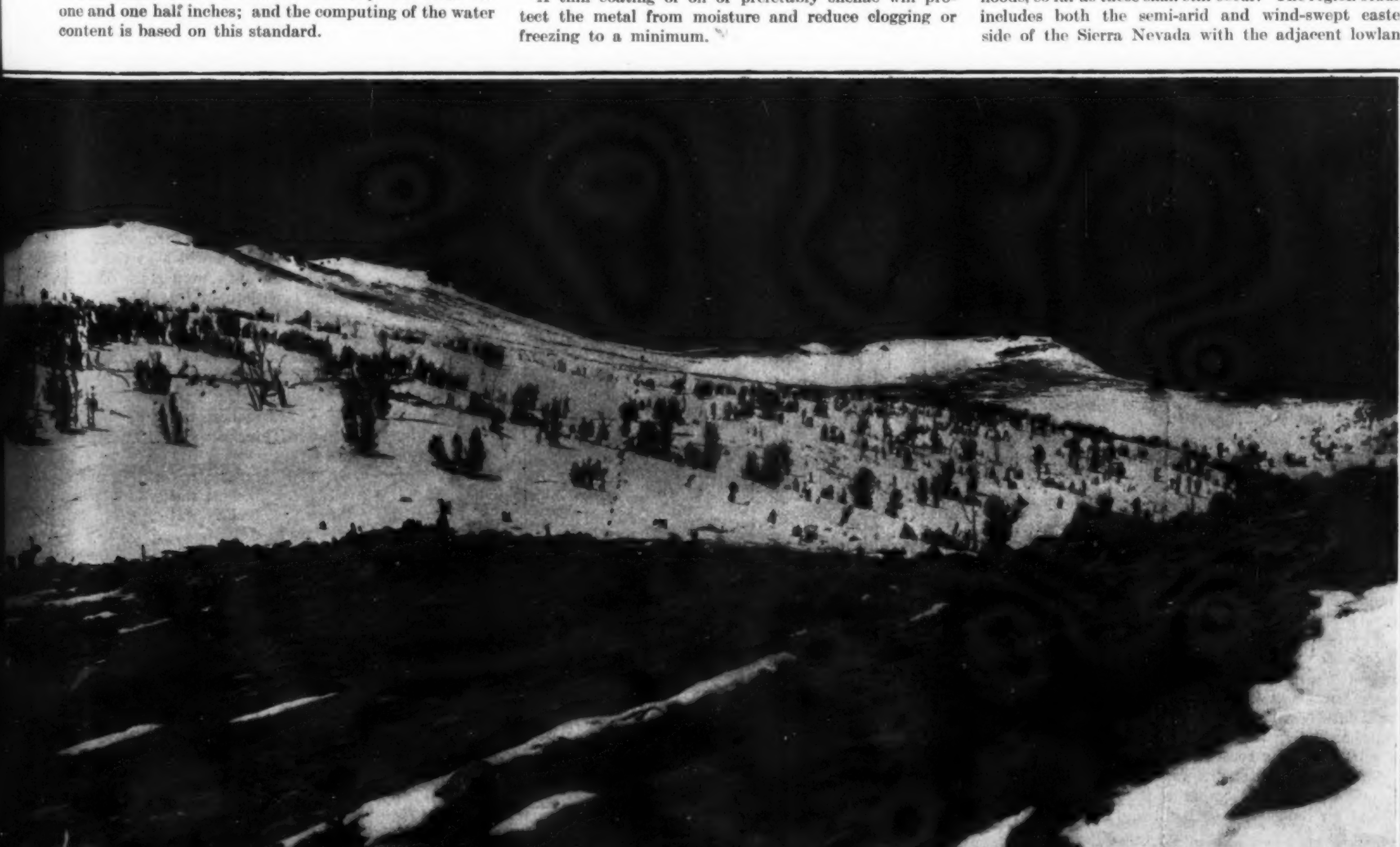
The spring balance (Fig. 7), whose dial is graduated to show the equivalent inches of water and is movable to permit the immediate adjustment of the 0— point to any sampler irrespective of its weight or the number of sections employed at the time, shows the net water equivalent of the sample of snow at a glance. The spring balance also contains a special pointer to facilitate accurate reading of the dial, and is made of aluminium to reduce weight. To eliminate vibration, the spring balance is hung from a supporting staff, whose iron-shod point readily penetrates all crusts. In fluffy snow, however, four metal wings or fins give the staff stability.

The sampler complete with attachments and containing sections enough to penetrate to the depth of twenty feet can be carried by two persons over mountain slopes, and has been carried on occasions by one.

A thin coating of oil or preferably shellac will protect the metal from moisture and reduce clogging or freezing to a minimum.

By the aid of the sampler and spring balance the study of the snow on the ground has reached greater precision than ever before. Since the spring of 1909 large areas of snow, both on mountain tops and in the lowlands, have been surveyed and their water content quantitatively determined. The increase in depth and density with elevation have also been studied, and seasonal forecasts of the moisture stored in the high mountains have been inaugurated for the assurance of the irrigationist, such as, for example, the forecast of the double store of moisture in the Sierra Nevada in 1911.

But the strength of the observatory staff has been employed in determining the principles that underlie the relation of mountains and forests to the conservation of snow. This work should lead ultimately to the improvement of the forests and the prediction of floods, so far as these shall still occur. The region studied includes both the semi-arid and wind-swept eastern side of the Sierra Nevada with the adjacent lowlands



10,800 Feet. […] Lines Show the Principal Courses of the Snow Measurements Made.

Southern Face of Mount Rose, Showing Effect of Timber Screens on Holding and Conserving the Snow.

Mount Rose Observatory in Winter at an Elevation of 10,800 Feet Above Sea-level.

and also the moister and more sheltered basin of Lake Tahoe where forests of varying types and densities occur.

Wherever forests or vegetation are found, the principle of shelter dominates all others. The forests anchor the snow when it falls and protect it against erosion after it has fallen. The forests also protect the snow from being evaporated and melted by sun and wind. In brief, the forests are a wind break as well as a shelter from the sun. However, a forest may be too dense to permit a maximum quantity of falling snow to reach the ground, or it may be too sparse to afford an effectual shelter against either wind or sun. In like manner, certain mountain slopes may afford better shelter from wind and sun than other slopes; and where the prevailing wind is from the southwest both of these qualities may be combined in a single slope.

These general principles are illustrated by the following data:

MEASUREMENTS ON SEMI-ARID EASTERN SLOPE OF SIERRA NEVADA.

COMPARISON OF THREE AREAS AT BASE OF MOUNT ROSE.

Elevation, 5,535 feet; measurements, March, 1909; 14, 11, and 35 stations, respectively.

a. Reforested area thickly covered with young pines averaging 30 feet in height.
Average depth of snow, 13.2 inches; equivalent water, 5.5 inches.

b. Deforested area dotted with clumps of manzanita and snow bush.
Average depth of snow, 5.6 inches; equivalent water, 2.4 inches.

c. Typical sage brush area.
Average depth of snow, 1.5 inches; equivalent water, 0.6 inches.

Of the snow found on this sage brush area, one third should be credited to the southern side of a gulch which offered considerable shelter from sun and wind. Furthermore, at least one fourth of the snow in the deforested area should be attributed to the influence of thickets of pine scrub. But even as the original figures stand, the reforested area has conserved two and one third times as much snow as the deforested area dotted with manzanita, and nine times as much as the typical sage brush area.

Comparison of Bare and Forested Mountain Tops.

SUMMIT OF MOUNT ROSE (Elevation, 10,800 Feet).

Course 1.—Elevation, 9,300 to 10,800 feet; measurements made April, 1910; 47 stations.

a. Unforested talus slope.
1. Cornice below observatory.
Snow, 52.5 inches; equivalent water, 25.1 inches.
2. Wind-swept slope.
Snow, 8.1 inches; equivalent water, 2.6 inches.
3. Protected slope.
Snow, 78.1 inches; equivalent water, 35.1 inches.
Total snow on talus slope, 40.8 inches; equivalent water, 18.4 inches.

b. Forested slope.
Snow, 88.6 inches; equivalent water, 41.1 inches.

The forested slope, therefore, contains an average water content one fifth greater than the unforested but protected slope above it, nearly twice as much water as the cornice at the apex of the mountain, over fourteen times the moisture conserved by the wind-swept slope, and more than twice the average water content of all three areas combined.

The superiority of the forested slope is made yet more convincing by comparing the increase of snow on it and on its nearest competitor, the protected slope above it:

FORESTED SLOPE.

March 1: Snow, 88.1 inches; water, 36.8 inches.
April 5: Snow, 88.6 inches; water, 41.1 inches.

PROTECTED SLOPE.

March 1: Snow, 81.3 inches; water, 32.3 inches.
April 5: Snow, 78.1 inches; water, 35.1 inches.

NET GAIN.

Forested Slope: Snow + 0.5 inches; water + 4.3 inches.
Protected Slope: Snow — 3.2 inches; water + 2.8 inches.

The gain for the period of five weeks is nearly one half greater on the forested slope than on the other. However, the increase in the relative density of the snow, due evidently to settling, is greater on the protected slope, for the relative density of the snow on this slope has increased from 0.397 to 0.450 (or 0.053) while on the forested slope the increase has been from 0.418 to 0.464 (or 0.046).

Course 2.—Elevation, 9,000 to 10,500 feet; measurements April, 1910; 52 stations.

a. Talus slope covered with low scrub.
Snow, 32.4 inches; water, 13.4 inches.

b. Talus slope slightly steeper than preceding and dotted with screens of timber 10 to 20 feet high.
Snow, 61.4 inches; water, 26.5 inches.

It is noteworthy that in season of normal or heavy precipitation the snow on the first slope rises as high as the tips of the scrub but no higher, for with the burial of the scrub beneath the snow, which the former's own branches have accumulated, the slope is exposed to the unobstructed sweep of the wind. If this scrub should be removed, the wind would practically denude the slope of snow.

VALUE OF TIMBER SCREENS ON THE LIPS OF CAÑONS.

A typical illustration of the value of timber screens on the lips of cañons, where both slope and timber unite in conserving the snow, is seen in the foreground of the panoramic view of Mount Rose. The cornice is deepest where the timber screen is highest and most impervious to the wind. On the other hand, the snow is very thin or entirely wanting on the unforested portion of the lip of the cañon. A part of the erosion, however, is due to the compression and consequent acceleration of the wind in the pass. The following comparison of a cross section of this cornice with a similar cross section of the cornice below the observatory reveals the relative merit of a slope when augmented by a timber screen as compared with a slope lacking such screen.

Slope possessing a timber screen, April 7, 1910.
Snow, 95.3 inches; water, 48.9 inches.

Slope lacking a timber screen, April 4, 1910.
Snow, 52.5 inches; water, 25.1 inches.

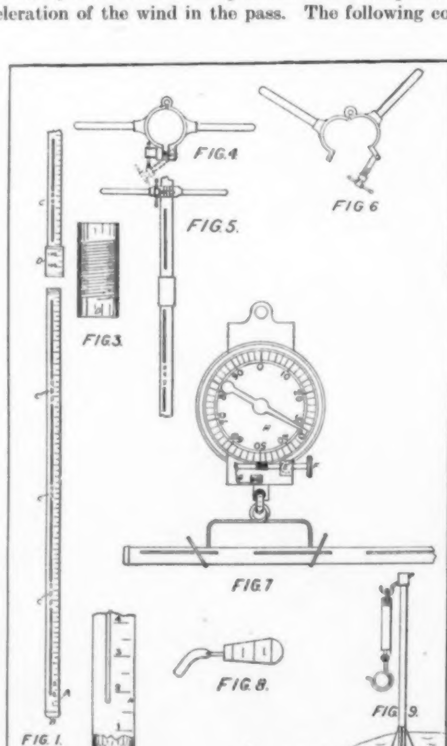


Diagram Showing the Different Parts of the Mount Rose Snow Sampler and Weigher.

MEASUREMENTS IN SEMI-MOIST BASIN OF LAKE TAHOE.

SEASONAL BEHAVIOR OF SNOW UNDER VARYING CONDITIONS OF FORESTATION AND TYPES OF FOREST TREES.

Series 1.—Comparison of Open Area with Forests of Pine and Fir.

Tahoe City: Elevation, 6,225 feet; January to April, 1910; approximately 65 stations.

a. Treeless Meadow:
January 7: Snow, 24.6 inches; water, 6.5 inches.
January 19: Snow, 41.6 inches; water, 9.8 inches.
March 11: Snow, 29.8 inches; water, 11.7 inches.
March 21: Snow, 20.6 inches; water, 8.4 inches.
April 10 to 13: Snow completely gone.

b. Forest of Pine and Fir:
January 7: Snow, 23.8 inches; water, 6.3 inches.
January 19: Snow, 40.4 inches; water, 8.4 inches.
March 11: Snow, 31.4 inches; water, 12.1 inches.
March 21 (after warm weather and rain):
Snow, 24.0 inches; water, 9.4 inches.
April 20: Snow, 1.3 inches; water, 0.6 inches.

c. Fir Forest:
January 7: Snow, 25.0 inches; water, 5.4 inches.
January 19: Snow, ... inches; water, ... inches.
March 11: Snow, 30.4 inches; water, 11.0 inches.
March 21 (after warm weather and rain):
Snow, 24.5 inches; water, 9.0 inches.
April 20: Snow, 7.1 inches; water, 2.7 inches.

Although the treeless meadow had the maximum store of snow at the beginning of the season, at the end the fir forest still retained one fourth of its total store after the meadow had been bare for a week. The more open forest of pine and fir, which at the height of the season possessed the maximum store of snow, now retained but one twentieth of it.

Series 2.—Comparison of Fir Forests of Varying Densities.

Blackwood Creek: Elevation, 6,225 feet; January to April, 1910; Approximately 90 Stations.

a. Open Forest of Pine and Cedar:
January 11: Snow, 24.3 inches; water, 5.8 inches.
January 17: Snow, 47.3 inches; water, 8.6 inches.
March 13 and 14:
Snow, 34.9 inches; water, 13.5 inches.
March 20: Snow, 28.9 inches; water, 11.3 inches.
April 25: Snow, 0.5 inch.; water, 0.2 inch.

b. Very Dense Fir Forest:
January 11: Snow, ... inches; water, ... inches.
January 17: Snow, ... inches; water, ... inches.
March 13 and 14:
Snow, 31.0 inches; water, 10.9 inches.
March 20: Snow, 26.3 inches; water, 9.3 inches.
April 25: Snow, 2.1 inches; water, 0.9 inch.

c. Fir Forest, Dense but filled with Glades:
January 11: Snow, 25.0 inches; water, 5.7 inches.
January 17: Snow, 50.7 inches; water, 9.2 inches.
March 13 and 14:
Snow, 42.7 inches; water, 16.5 inches.
March 20: Snow, 36.9 inches; water, 14.5 inches.
April 25: Snow, 7.8 inches; water, 3.2 inches.

It is evident from the above comparison that density is not the only factor in the conservation of snow, for the very dense forest has conserved only one twelfth of its snow till the end of the season despite the fact that the rate of melting in it is much lower than in the forests of lesser density. On the other hand, the fir forest, filled with glades, has conserved approximately one fifth of its store of snow despite the fact

that the rate of melting in it is as rapid as in the open forest of pine and cedar, which has conserved only one sixty eighth of its store of snow. The reason for this is found in the presence of the glades which have greatly increased the snow-gathering capacity of the forest. In fact, it is the snow drifts lying in the sheltered portions of these glades that constitute the bulk of the snow still unmelted.

The principle underlying the above phenomena is the following: 1. The crowns of the forest trees catch a certain proportion of the falling snow and keep it suspended and exposed to rapid evaporation. The proportion of snow thus suspended corresponds to the density and width of the crowns of the individual trees and the closeness of the trees to each other. 2. On the other hand, the snow that reaches the ground is in turn even more effectually conserved in proportion to the density of the forest cover than it was dissipated while reaching its resting place. But the snow that falls upon unforested areas, although it may reach the ground undiminished in quantity, becomes at once subject to gradual dissipation by wind and sun.

THE EFFECT OF SUN AND WIND.

How potent the forces of wind and sun are is shown by the following experiments:

a. Temperature of Snow When Shaded and When Exposed to Sun.

Snow bank north of pine tree screen, April 22, 1910.

The thermometers were inclosed in sealed glass tubes. The thermometer with white bulb represents the effect of heat within the snow when the latter is free from opaque bodies; the thermometer with blackened bulb represents the absorption of heat by opaque bodies beneath the snow.

	Series 1.—Twelve inches beneath the snow.		Series 2.—Two inches beneath the snow.
	White bulb. Deg. Fahr.	Black bulb. Deg. Fahr.	White bulb. Deg. Fahr.
Area in sun.			Area in sun.
8 A. M.	32.5	32.7	35.0
9 A. M.	32.5	32.7	37.0
10 A. M.	32.5	33.0	40.7
In shade.			
11 A. M.	32 3	32.5	44.0
In sun.			
12 M.	32.6	33.0	48.8
In mottled shade.			In mottled shade.
1 P. M.	32.2	32.5	45.2
Shade now heavier.			
2 P. M.	32.0	32.0	....

NOTE:—The temperature within the snow did not rise above 32 deg. Fahr. during the remainder of the day.

The temperature of the free air rose on this day from 31 deg. Fahr. to 60 deg. Fahr. The sky was practically unclouded, and the heat increased steadily from morning until early afternoon, when it fell again.

The immediate effect of shade is shown in Series 1 by the drop in the temperature at 11 A. M. and its recovery at 12 M.; also by the approximation of the white and black bulb thermometers during the period of shade to the same temperature reading. In Series 2 the temperature was naturally higher than in Series 1 and rose steadily until shade intervened.

b. Evaporation of Snow.

Base of summit of Mount Rose; elevation, 9,000 feet; April 30, 1911.

On snow dome behind small timber screen. The evaporation pans were 10½ inches in diameter and 6 inches deep.

Gross Weight of Pans and Snow, in Ounces.	Period. Hours.	Temperature. Deg. F.	Wind. Miles.	Loss by Evap. Oz.
Pan No. 1, apex of dome, 117	13¼	24.7-31	431	5
Pan No. 2, center " 120	13½	24.7-31	431	4¾
Pan No. 3, tail " 119	13⅛	24.7-31	431	4

This experiment was made at night. The temperature was below freezing and the snow itself was frozen hard when placed in the pans. Yet under the wind movement, that averaged slightly over thirty-three miles an hour, a loss of approximately .08 to 10 inch water content occurred or one one hundred twentieth of the snow on the ground. This extraordinary evaporation, which demonstrates sharply the necessity of dense timber screens on exposed slopes, finds its counterpart in a relatively small evaporation in the forested areas of the Tahoe Basin.

THE IDEAL FOREST.

From the foregoing facts it follows that the ideal forest from the view point of conservation is the one that can conserve the maximum amount of snow until the close of the season of melting. Such a forest should not be dense enough to prevent the snow from reaching the ground and yet should be sufficiently dense to afford ample shelter from sun and wind. The fir forest possessing a maximum number of glades or a forest of mountain hemlock meets these requirements both theoretically and practically. However, glades can be produced in any dense forest by the simple operation of cutting, the diameter of each glade being so proportioned to the height of the trees around it that the snow in early spring is effectually screened from the sun. Such a forest, when viewed from above, would resemble a gigantic honey comb, the glades of the forest being equivalent to the cells of the comb.

THE EFFECT OF ELEVATION.

Elevation is one of the largest factors in the conservation of snow. A difference in elevation of even 1,000 feet effects a marked change in the store of available snow. A significant example is the Ruby Mountains in eastern Nevada, which attain an altitude of 11,000 to 12,000 feet but are covered with scant verdure except brush. These mountains are the main source of the Humboldt River, the longest river in Nevada and one whose maximum flow is normally retarded by the elevation of its snow fields until early June—a fact of the utmost consequence to the ranchers along its course. On the other hand, the Truckee River, which rises in the Sierra Nevada and is fed by a region partially forested but 2,000 feet lower than the Ruby Mountains, attains its maximum flow in May, a date too early for the most efficient use of the water. A striking feature of the value of elevation is the continued accumulation of snow at the higher levels long after the snow at the lower levels has begun rapidly to disappear.

The following table of snow measurements at various elevations and exposures in the Tahoe Basin suggests the possibilities of a detailed study of this question:

COMPARISON OF ELEVATIONS AND SLOPES.

Tahoe Basin, April 27 to May 5, 1910; 7 to 40 Stations.

Blackwood Creek:
- 6,225 feet, level (fir forest with glades); snow, 7.8; water, 3.2.
- 6,950 feet, northern exposure (open fir forest); snow, 24.2; water, 10.3.

Rubicon Range:
- 7,640 feet, northern exposure (red fir forest); snow, 32.8; water, 14.
- 8,100 feet, northern exposure (mountain hemlock forest); snow, 82.3; water, 37.3.

Mount Tallac:
- 8,000 feet, southern exposure (timber sparse); snow, 50; water, 25.
- 9,000 feet, southwestern exposure (unforested); snow, 71; water, 35.9.

SEASONAL SNOW SURVEYS AND FORECASTS.

Owing to the wide divergence between the snow fall and snow conservation at the lower elevations (where habitations exist and routine observations of snow fall are generally made) and at the higher levels, and owing also to the fact that the snow conditions at the former are only symptomatic of those existing at the latter, systematic surveys of the snow fields in the high mountains were inaugurated early in 1909 as the only feasible and exact method of determining the moisture available for irrigation. Seasonal snow tanks or gages proved quite inefficient because of high winds and furnished no clue to the snow actually on the ground, while one or more parties of men, measuring with snow samplers along definite typical courses, could quickly and accurately determine the storage of snow. Evaporation measurements have since been added to the snow survey in order that due allowance may be made for loss of moisture upward. The only factor now left undetermined is that of absorption by the soil. This, however, can be roughly determined for given localities by subtracting the stream flow from the net moisture content of the snow field, that is, the moisture content after due allowance has been made for evaporation.

The following surveys in the Mount Rose watershed for 1910, 1911, and 1912 reveal the great difference between seasons, and between the depth and density of the snow:

SEASONAL SNOW SURVEY—SUMMIT OF MOUNT ROSE. 9,300 to 10,800 feet; 47 Stations.

1910 (approximately a normal year), April: Snow, 51.8 inches; water, 23.5 inches; relative density, 45 per cent.

1911, February: Snow, 89.5 inches (173 per cent of 1910); water, 36.7 inches (156 per cent); relative density, 41 per cent.

1912, April: Snow, 35.2 inches (68 per cent of 1910); water, 13 inches (55.3 per cent); relative density, 37 per cent.

The unreliability of the method of estimating water content by depth of snow alone is evident from the variation in the relative density of the snow for the various years. The forecast of an excessive snow storage for 1911 and its probable maximum was made after the survey in February of that year. To allay the anxiety of ranchers and power companies during the present season of 1912 careful measurements of the high snow fields were made until June. The seasonal survey is now being extended to the study of the relation of typical slopes to each other to determine a method of forecasting the probability and magnitude of floods.

THE CONTROL OF STREAM FLOW.

There can no longer be any question of the direct influence of forests in delaying the melting of the snow and thus in retarding stream flow at the very time when floods normally occur. It is also equally true that forests, if too dense, fail to attain their maximum efficiency as conservers of snow. On the other hand, the planting of timber screens at strategic points on exposed slopes will greatly increase their capacity to store more snow.

There are two types of reservoirs—the snow reservoir, formed by mountain cliff or forest to hold the snow in its original form, and the water reservoir below to impound the flood waters of the streams. The development of the former is the immediate and feasible task of the forester, the construction of the latter is the work of the engineer. The first type alone should normally control the mountain streams of moderate length such as those intimately associated with the Appalachian and Western ranges. But both types, if used to supplement each other, should insure the maximum control of all streams.

Using Selenium During an Eclipse.

SELENIUM was used to take note of the last eclipse of the sun in a very satisfactory way by M. L. Ancel, who is an experienced Paris scientist engaged in wireless telegraphy and researches upon selenium. A great factor in his success is a new selenium cell of his construction, and he is able to place the metal conductors of the cell much closer together than usual so as to have a series of gaps of but 0.04 millimeter (0.0016 inches) which are bridged over by the selenium, while in ordinary cells the distance is as much as 1 millimeter (0.04 inch). As the selenium layer is very thin at the same time, the result is a more sensitive cell than usual and it has much less inertia. A cell of 1×1½ inch surface was lighted by the sun during the eclipse, and he could obtain a current through it with a 2-cell battery which was 20 times the current given through an ordinary cell. Thus all the variations in the sun's light are instantly followed. He used a small heliostat to keep the sun's rays constantly reflected onto the cell, and the current of the cell passed into a registering instrument which gave a record on a paper band. The latter outfit consists of a sensitive galvanometer which sends a beam of light from a lamp onto a band of graduated photographic paper rolled up by a clockwork drum, so that after developing, the curve traced on the paper shows the variations in the value of the sun's light as represented by the value of the current through the selenium cell. His apparatus was set up in a tent which had been erected in an open field in the suburbs of Paris. By means of a small antenna mounted upon poles he was able to receive the time signals sent out by the Eiffel Tower, and these signals were specially sent by the Tower plant during the time of the eclipse. Using a telephone head band, he was able to receive the time signals and to repeat these at once by closing a switch so as to make an automatic record by electric means upon the photographic paper. Thus he secured the indications on the band as regards the time, while the galvanometer at the same time recorded the sun's light in a continuous line upon the paper. The result was a remarkably good curve which showed at a glance just how the sun's light diminished down to the lowest point when at the maximum of the eclipse, then it rose from this point in a very regular way until it reached the level corresponding to full sunlight at the end of the eclipse. There are small oscillations in the recorded line which are due to vibrations of the ground from automobiles passing near, also to the working of the heliostat, but these did not hinder the good appearance of the record. The selenium also shows that the sun's light was lower in the morning at 10:45 when the eclipse commenced than at the end of the eclipse at 2:50 in the afternoon, as might be expected, so that the record line rises to a higher point than at the commencement. This is the first time that a continuous recorded curve of an eclipse of the sun is obtained, and M. Ancel's results awakened much interest. Before this, Wulf and Lucas made experiments at the Tortosa observatory in Spain, but they limited this to noting different points separately so as to obtain a curve made up of a number of points, and their curve was not automatically recorded as in the present case. (See curve on p. 268, *Comptes Rendus*, No. 4).

The Influence of Aurora Borealis Upon Electric Waves.—Spitzbergen stands in wireless communication with the mainland of Europe through the stations of Greenharbor, near Hammerfest. We read in *Cosmos* that considerable trouble has been experienced through the interference of the Aurora Borealis, which at times almost totally obliterates the signals.

Pressure of Coal on Storage Bin Walls*

The Difference Between Anthracite and Bituminous

WHEN designing bins for coal or other material of similar nature, the first factor to be determined is the pressure of the coal against the retaining walls. Owing to the fact that there is a certain amount of friction between the individual pieces of coal, this pressure cannot be considered or calculated in the same way as the pressure of water or any other fluid contained in a bin or reservoir.

If coal is stored on a floor or other horizontal surface in a pile not constrained at the sides, it will assume a cone shape as in Fig. 1 (diagram). The angle which the sides of the cone form with a horizontal plane depends upon the kind of coal stored and, to some extent, upon the size of the coal. "The angle of repose" is then the angle which a pile of coal will assume when not constrained by retaining walls. For anthracite coal it may be assumed to have an average value of 27 degrees and for bituminous coal an average value of 35 degrees. This angle is the basis of the calculation of the horizontal pressure upon the walls exerted by coal contained in a storage bin.

In the formula for calculating the horizontal pressure on the retaining wall per foot of length, the angle a, Fig. 2, is used. This angle is one half of the angle which the line of repose or natural slope line makes with the vertical, hence:

$$a = \frac{90° - \beta}{2}$$

β being the angle of repose. In the case of anthracite coal we then have:

$$a = \frac{90° - 27°}{2} = 31 \text{ degrees } 30 \text{ minutes,}$$

and in the case of bituminous coal:

$$a = \frac{90° - 35°}{2} = 27 \text{ degrees } 30 \text{ minutes.}$$

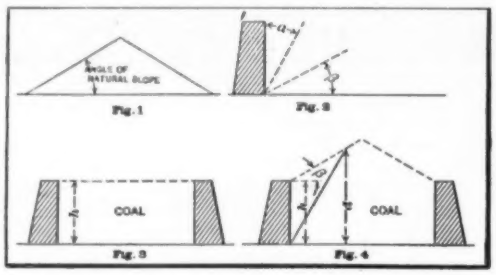
Coal can be stored in a bin either with the top surface horizontal, as shown in Fig. 3, or with the top surface cone-shaped, as shown in Fig. 4. The pressure upon the retaining wall evidently is greater in the cases shown in Fig. 4 than in that shown in Fig. 3. The formula for the total pressure on the retaining wall per foot of length for a bin containing coal with the surface horizontal, as shown in Fig. 3, is:

$$P = \frac{wh^2}{2} \tan^2 a$$

in which

P = total pressure per foot of length on retaining wall, in pounds,
w = weight of coal per cubic foot, in pounds,
h = height of retaining wall, in feet,
a = angle as shown in Fig. 2 = 31 degrees 30 minutes for anthracite coal, and 27 degrees 30 minutes for bituminous coal.

The weight w per cubic foot may be assumed as 52 pounds for anthracite coal and 47 pounds for bituminous coal.



Angles Used in Formulæ for Calculating Pressure on Storage Bin Walls, and Different Methods of Storing Coal.

The pressure upon the retaining wall when the coal is stored as indicated in Fig. 4, is obtained by the same formula as that used for bins with the coal surface horizontal except that instead of the factor h^2 in the formula, a value equal to $1.454\ h^2$ for anthracite coal, and a value equal to $1.574\ h^2$ for bituminous coal is used. The formula then is:

$$P = \frac{w \times 1.454\ h^2}{2} \tan^2 31° \ 30' \text{ for anthracite coal, and}$$

$$P = \frac{w \times 1.574\ h^2}{2} \tan^2 27° \ 30' \text{ for bituminous coal.}$$

The constants 1.454 and 1.574 express the ratio between d and h in Fig. 4 for anthracite and bituminous coal, respectively. These ratios can be applied directly only when the angles of slope remain 27 and 35 degrees, respectively.

The tables in the accompanying Data Sheet Supplement have been calculated by means of the formula given. The column giving the pressure on the lowest foot is obtained by subtracting the total pressure for a wall one foot lower in height, from the total pressure for the wall under consideration. For example, if the pressure on the lowest foot of a wall 10 feet high is to be calculated, subtract the total pressure for a 9-foot wall from the total pressure for a 10-foot wall. Hence, for anthracite coal with the surface horizontal:

$$978 - 792 = 186 \text{ pounds.}$$

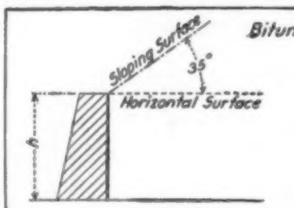
which value, it will be found, agrees with that given in the accompanying Data Sheet Supplement.

* Reproduced by courtesy of the Editor of *Machinery*.

The Margine of the Olive

IN the process of pressing olives to obtain oil, there is also given off a considerable amount of watery liquid which is known as "margine," and as it contains quite an amount of mineral and organic salts, it is now proposed to extract these by evaporation. The liquid has a density of 1.05 or 1.06 and gives 175 parts of dry matter per 1,000, this yielding 24 parts of mineral matter and 4 parts nitrogenous products. In a recent report, M. Bertainchand brings out the richness in potash, and states that there is an average of 800 grains of oxide of potassium per gallon of liquid, this being equal to 50 per cent of the weight of the ash. For this reason there have now been installed in the Tunis region plants for dessication of the liquid from olives. In this case the liquid is evaporated and the dry product is burned so as to secure the ash. This contains 62 per cent of soluble salts, or 27 per cent carbonate of potash, 25 of chloride of potash and 4 of sulphate, also 6 per cent carbonate of soda. The ash is exhausted by water as in the lye process and then the solid salts are obtained by evaporating, after which they are refined and crystallized. Thus when concentrated, the sulphate crystallizes out at first, and then the chloride, leaving a salt which contains the carbonates. The whole product is worth about $1 per 100 pounds.

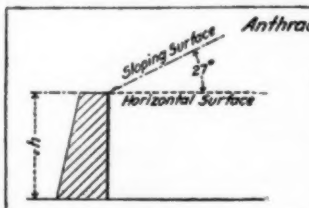
Bituminous Coal Bins.



The table gives the horizontal pressure (in pounds) exerted by bituminous coal against a vertical retaining wall, per foot of length, both for horizontal and sloping surface of coal stored. Weight of coal, 47 pounds per cubic foot.

Depth h in feet	Horizontal Surface		Sloping Surface		Depth h in feet	Horizontal Surface		Sloping Surface	
	Total Pressure	Pressure on lowest foot	Total Pressure	Pressure on lowest foot		Total Pressure	Pressure on lowest foot	Total Pressure	Pressure on lowest foot
1	64	6.4	10	10	26	4305	325	6760	510
2	25	19	40	30	27	4641	338	7290	530
3	57	32	90	50	28	4993	350	7840	550
4	102	45	160	70	29	5358	363	8410	570
5	159	57	250	90	30	5732	376	9000	590
6	229	70	360	110	31	6122	389	9610	610
7	312	83	490	130	32	6523	401	10240	630
8	407	96	640	150	33	6935	414	10890	650
9	516	108	810	170	34	7362	427	11560	670
10	637	121	1000	190	35	7778	440	12250	690
11	770	134	1210	210	36	8253	452	12960	710
12	917	146	1440	230	37	8754	465	13690	730
13	1076	159	1690	250	38	9193	478	14440	750
14	1248	172	1960	270	39	9682	490	15210	770
15	1433	185	2250	290	40	10192	503	16000	790
16	1630	197	2560	310	41	10669	516	16810	810
17	1840	210	2890	330	42	11236	529	17640	830
18	2063	223	3240	350	43	11797	541	18490	850
19	2298	236	3610	370	44	12331	554	19360	870
20	2548	248	4000	390	45	12968	567	20250	890
21	2809	261	4410	410	46	13478	580	21160	910
22	3083	274	4840	430	47	14100	592	22090	930
23	3369	287	5290	450	48	14679	605	23040	950
24	3669	299	5760	470	49	15275	618	24010	970
25	3981	312	6250	490	50	15925	631	25000	990

Anthracite Coal Bins.



The table gives the horizontal pressure (in pounds) exerted by anthracite coal against a vertical retaining wall, per foot of length, for both horizontal and sloping surface of coal stored. Weight of coal, 52 pounds per cubic foot.

Depth h in feet	Horizontal Surface		Sloping Surface		Depth h in feet	Horizontal Surface		Sloping Surface	
	Total Pressure	Pressure on lowest foot	Total Pressure	Pressure on lowest foot		Total Pressure	Pressure on lowest foot	Total Pressure	Pressure on lowest foot
1	9.8	9.8	14.2	14.2	26	6611	499	9613	725
2	39	29	57	43	27	7129	518	10366	754
3	88	49	128	71	28	7668	538	11149	782
4	156	68	228	100	29	8225	557	11938	811
5	244	88	355	128	30	8802	577	12797	839
6	352	108	512	156	31	9398	597	13665	867
7	479	127	697	185	32	10015	616	14561	896
8	626	147	910	213	33	10650	636	15486	924
9	792	166	1152	242	34	11306	655	16439	953
10	978	186	1422	270	35	11980	675	17420	981
11	1183	205	1721	299	36	12675	694	18429	1010
12	1408	225	2048	327	37	13389	714	19467	1038
13	1653	244	2403	355	38	14123	733	20533	1066
14	1917	264	2787	384	39	14875	753	21629	1095
15	2200	284	3199	412	40	15648	773	22752	1123
16	2504	303	3640	441	41	16440	792	23904	1152
17	2826	323	4110	469	42	17252	812	25084	1180
18	3169	342	4607	498	43	18083	831	26293	1209
19	3531	362	5133	526	44	18934	851	27530	1237
20	3912	381	5688	555	45	19804	870	28793	1263
21	4313	401	6271	583	46	20695	891	30090	1297
22	4733	421	6882	611	47	21605	910	31412	1322
23	5174	440	7522	640	48	22533	929	32763	1351
24	5633	460	8191	668	49	23482	949	34143	1379
25	6113	479	8887	697	50	24450	968	35550	1407

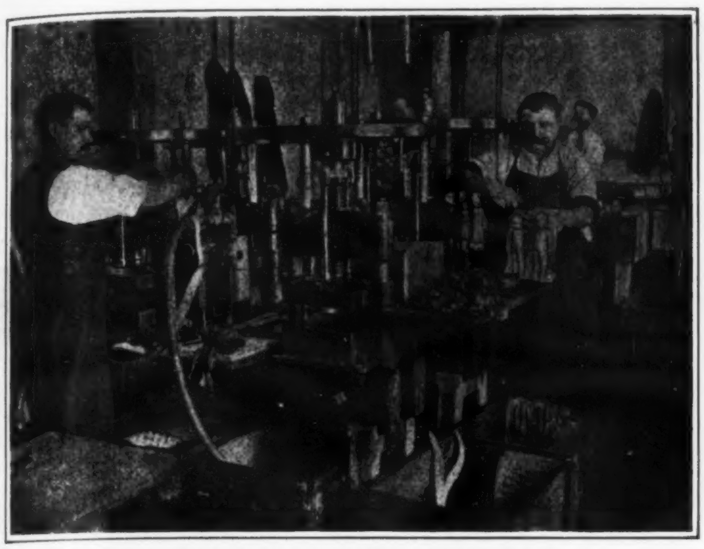


Fig. 1.—Shaping Thin Celluloid by Compressed Air.

Fig. 2.—Washing Vats, Centrifugal Drying Machines, and Shredding Mills.

The Story of Celluloid*

How the Material is Manufactured, and Made into Useful Articles

The singular origin of celluloid and the variety of uses to which it is adapted make it one of the most interesting of the creations of modern industry. It is employed as a substitute for horn, tortoise shell, glass, rubber, paper, cardboard, even linen (in collars). It may be transparent or opaque, glossy or dull, flexible or brittle, white or colored, and it can be molded into any form. Discovered almost by chance, it was promptly manufactured by a process so nearly perfect that no essential change has been made in thirty years.

Fig. 3.—Hydraulic Press for Drying Nitro-cellulose.

* Adapted from an article by A. Chaplet, in *La Science au XXme Siècle*.

Although various substitutes have been produced by totally different methods, the production of celluloid increases yearly. Celluloid and each of its rivals has its own special field, and the various industries thrive side by side.

In 1865 Parkes, of Birmingham, mixed guncotton with naphtha and vegetable oils, and thus obtained plastic insulating substances which were made in large quantities, but at a cost which drove them from the market when celluloid appeared. In 1869 the Hyatt brothers, American printers, after experimenting with many other substitutes for the gelatin of inking rollers, obtained their desideratum by mixing nitrated cotton with alcohol and camphor. The evaporation of the alcohol left a homogeneous, transparent, elastic mass—celluloid.

Celluloid is a mixture of complex and still imperfectly known constitution, into which various substances may be introduced—castor oil to give flexibility, cheap substitutes for camphor, fire-proofing salts, coloring matter and fillers. Cellulose is still an absolutely indispensable ingredient and a mixture of nitro-cellulose and camphor forms the basis of the majority of good commercial brands of celluloid.

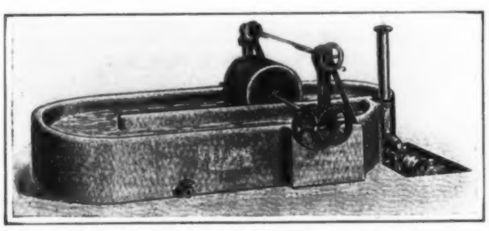


Fig. 4.—Nitro-cellulose Mill.

Celluloid is not made, as is sometimes asserted, directly from wood or rags. The start must be made either from raw cotton or from very thin paper. The cotton or paper is transformed into nitro-cellulose by the action of a mixture of concentrated nitric and sulphuric acids, the function of the sulphuric acid being to absorb the moisture produced by the reaction. The nitration is a very delicate operation, and is conducted in earthenware vats or in special machines which facilitate the removal of the spent liquor. The smallest possible quantity of acid should be used—say 4 pounds of 61 per cent nitric acid and 9 pounds of 95 per cent sulphuric acid for each pound of paper. As soon as the nitration is finished the spent liquor is extracted from the paper as completely as possible by means of a press or a centrifugal machine. The spent baths, after they have fortified by adding concentrated acids, are used for subsequent operations.

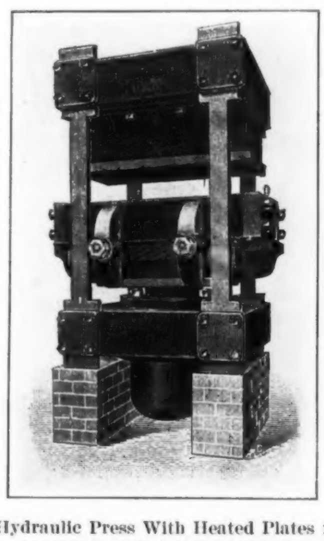


Fig. 5.—Hydraulic Press With Heated Plates for Pressing Sheet Celluloid Into Blocks.

The nitrated paper is washed thoroughly and is then

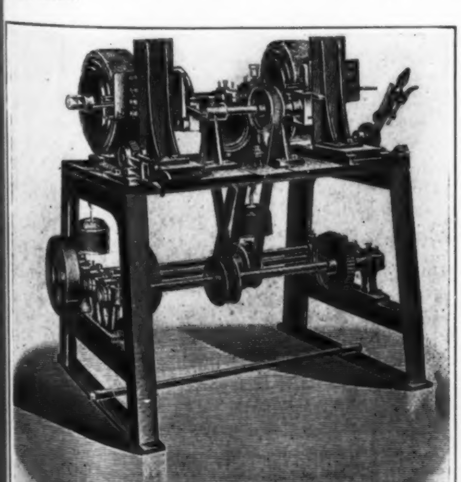


Fig. 6.—Machine for Polishing Articles of Celluloid.

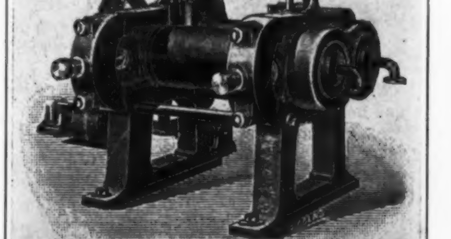


Fig. 7.—Machine for Rolling Sheet Celluloid.

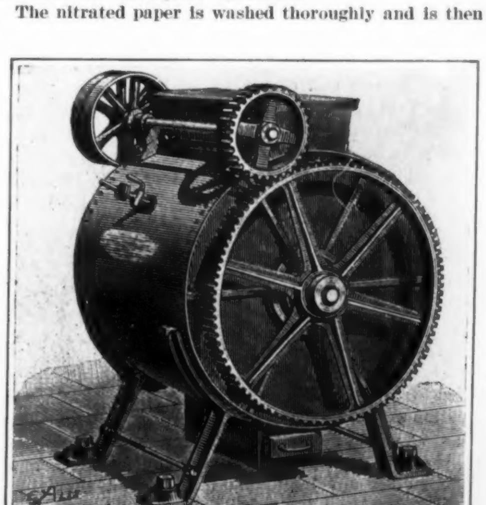


Fig. 8.—Viscose Kneader.

ground in a sort of paper mill (Fig. 4). The homogeneous nitro-cellulose pulp thus produced is bleached by the successive action of an acidulated solution of potassium permanganate and a bath of sodium bisulphite. Javelle water is employed for bleaching in a few factories. The bleached pulp is washed, drained and partially dried in centrifugal machines. (Fig. 2.) The drying is completed by wrapping the pulp in felted cloths, and subjecting a pile of the "cakes" thus formed to the action of a hydraulic press (Fig. 3). After the first pressing the wet cloths are exchanged for dry ones, and the operation is repeated until the mass is quite dry.

The camphor is then added by kneading the nitrocellulose with a solution containing about 6 pounds of camphor to each gallon of alcohol. The homogeneous camphorated mass is rolled into sheets between steam-heated cylinders of cast-iron (Fig. 7). The distance between the cylinders can be regulated so that the thickness of the sheet can be reduced to a few millimeters by repeated rollings. A pile of these sheets is transformed into a thick block of celluloid by subjecting it to great pressure (more than a ton to the square inch) for five to ten hours in a hydraulic press, the plates of which are heated by steam (Fig. 5). Although these blocks are quite homogeneous they are often cut up into thin slices and again consolidated by heat and pressure.

Celluloid is very plastic when hot and in this condition it can be made to assume any desired form. Rods and tubes are made by cylinder and piston machines from which the hot plastic mass is forced through circular and annular orifices.

Sheets of celluloid, obtained by slicing or rolling, are polished by pressing them in a hydraulic press between hollow plates of nickel-plated steel, which are heated to about 175 deg. Fahr. by injecting high-pressure steam for a few minutes, and are then chilled by admitting cold water.

From these sheets, and the other forms in which celluloid leaves the factory, various articles are made with the aid of saws, punches, pattern-knives, lathes, chisels, rasps, emery wheels and other tools, but the most economical and most frequently employed method consists simply in molding the celluloid to the desired form by pressing it very forcibly between bronze matrices attached to hollow plates heated by steam. The petals of artificial flowers and other very thin objects of celluloid are shaped in the press or by the action of compressed air (Fig. 1), after they have been softened by immersion in hot water. The parts of an object are cemented together with a solution of celluloid and the whole is finished by painting with acetic acid or acetone, either of which liquids forms a sort of varnish by dissolving the superficial stratum of celluloid.

Celluloid can be worked with machine tools similar in principle to those used by workers in wood and metal. The hand saw and the file, which were formerly employed in making combs of celluloid, have been replaced by a series of machines through which each comb passes successively. The first machine cuts pieces of sheet celluloid of the proper size and shape, the second makes one edge thinner than the other, the third cuts the teeth, the fourth shapes their points, etc. The surface is finished by grinding on revolving wheels or stones (Fig. 6).

In order to economize the rather expensive material a machine (Fig. 9) has been invented which cuts two combs, with their teeth opposed and interlocking, from one plate of celluloid, with practically no waste.

In addition to the ordinary celluloid, special varieties are made for special uses. Marbled celluloid is obtained by pressing together shreds of celluloid of various colors.

The celluloid of "American linen" collars is made white and opaque by loading it with zinc white and is made flexible and elastic by an addition of castor oil. Two thin sheets of this material, cut to the shape of a collar, are moistened with alcohol and cemented by pressure to an interposed piece of muslin. The fold, the buttonholes, the imitation seams, etc., are made by a series of machines. Each collar passes through twenty hands before it is boxed.

The merits of celluloid have been pointed out, but its demerits must not be overlooked. Celluloid is rather costly, owing to the high price of the camphor which it contains. It is also very inflammable, as it is composed principally of nitro-cellulose, the essential ingredient of the smokeless powder employed in modern warfare. Inventors have striven to remedy the last-named by adding salts which, when heated, either form a coating that excludes the air, or evolve gases like ammonia or sulphur dioxide, which prevent combustion. But these additions introduce so many inconveniences in return for a questionable improvement that they are little employed in practice. Acetanilid and other cheap substances are sometimes substituted, not for all of the camphor, but for a greater or smaller part, according to the use for which the celluloid is destined. The cost is diminished also by adding gelatin dissolved in glycerin or acetic acid, casein, or maisin, a gluten extracted from the spent maise of distilleries. Ceresin, naphthalin, rosin, glycerides, and other substances are proposed in various patents, but these processes produce inferior celluloid, and few of them have ever been practically worked.

Plastic masses less inflammable than celluloid can be made by treating cellulose with other agents than nitric acid. Viscose, or cellulose xanthate, is obtained by kneading 200 pounds of paper pulp with 300 pounds of a 20 per cent solution of caustic soda during 48 hours in the machine shown in Fig. 8, and then kneading the mixture with 100 pounds of carbon disulphide. When viscose, which is soluble in water, is cast in molds and dried at 80 deg. Fahr. for 30 hours, the result is "viscolith," which is less inflammable and cheaper than celluloid, but more brittle, and, therefore, of limited utility. Even when mixed with cork dust, rubber, etc., it resembles ebonite rather than celluloid.

Cellulose can also be combined with acetic, formic,

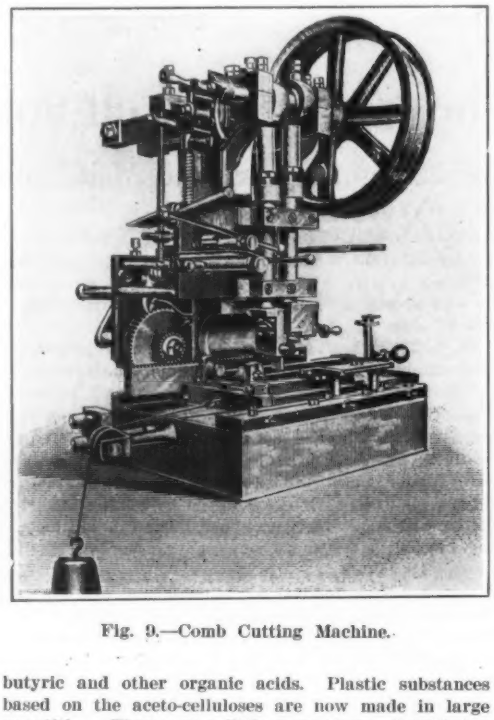


Fig. 9.—Comb Cutting Machine.

butyric and other organic acids. Plastic substances based on the aceto-celluloses are now made in large quantities. They cost a little more than celluloid, but they are not easily inflammable and they are consequently employed extensively for kinematograph films. There are many patents, but the process nearly always consists essentially in kneading cotton wool for several hours with a mixture of acetic acid and acetic anhydride, to which a little sulphuric acid is added, as a catalyzer. Sometimes benzine is added to prevent the mixture becoming pasty. The mass is washed with water or benzine and the aceto-cellulose is freed by the action of a centrifugal separator, from the residual acids, which are used again. By subsequent secret processes several different commercial products, named "cellite," "acetolith," etc., more or less similar to celluloid, are obtained. As a rule they are rather soft and require the addition of camphor to harden them. At present they are little used, except for photograph films, insulating tape, varnishes and textile dressings.

"Lactite," "cornalith" and "galalith" are plastic masses derived from the casein of milk, rendered insoluble by various processes. This result can be obtained by kneading the casein with pulverized marble, solutions of borax, potash, etc. The only method in practical use, however, is the treatment with formol. The resultant product, "galalith," is non-inflammable, hard, a good insulator, and almost as easily workable as celluloid, but more brittle and liable to crack. It has been proposed to remedy this defect by the addition of acetone. Galalith is made by heating and pressing to dryness a paste of pulverized commercial casein and water, and immersing the solid product in formol (formic aldehyde). It is used as the material of buttons, cigar holders, handles of brushes and knives, and other articles in which flexibility is not required and the odor of camphor is objectionable.

"Bakelite" is a plastic substance obtained by Dr. Baekeland by the action of formal upon the phenols. By varying the conditions of the reaction a number of different products—a morphous, crystalline, liquid, pasty, dry—can be produced. In practice a more or less viscous liquid variety is mixed with inert powders, molded into the desired form and then heated, under pressure, to nearly 350 deg. Fahr. in an apparatus called a "bakelizer." In this operation the material is hardened and rendered insoluble by a sort of molecular condensation. Objects can be covered with a very hard lacquer by coating them with the formo-phenol liquid and then "bakelizing" them, and soft, porous wood can be made hard and strong, and preserved from decay, by soaking in the liquid and "bakelizing."

The plastic materials produced by the action of formol, alum and chromic acid upon gelatin are very elastic, and resemble rubber rather than celluloid.

There are now in France ten large celluloid factories which employ more than 2,000 persons and produce annually more than 6,000 metric tons of celluloid, from 3,000 tons of paper pulp, 20,000 tons of sulphuric and nitric acids, 1,250 tons of camphor and 1,400,000 gallons of alcohol. In Paris alone, the manufacture of small celluloid wares gives employment to thousands, and half of the celluloid combs used in the entire world are made in France. On the other hand, France has only one celluloid collar factory, while England and Germany have several each. In the whole world nearly 1,000 metric tons of celluloid are used annually in the production of collars and cuffs (at the rate of 5,000 dozen per day), and ten million dollars' worth of celluloid and aceto-cellulose are employed in making 62,000 miles of kinematograph film. The products of most of the French factories, although they are not imitations, but genuine celluloid, are sold under fancy names—"ozonnite," "loreid," etc.—because the name "celluloid" is copyrighted by the Hyatt firm, which has a branch factory near Paris.

Celluloid is still made in larger quantities than any of its substitutes. It is almost impossible to ascertain the order of importance of these substances, owing to the secrecy maintained by the producers and the diversity of application of the products. Viscose, for example, is used rather for artificial silk and varnishes, than for solid articles.

Hitherto the high price of celluloid and its substitutes has restricted their employment to the production of small objects, but there is a manifest tendency to cheapen their production, which will greatly extend their field of application. Some day, perhaps, a cheap plastic material will be produced by prolonged grinding and maceration of wood pulp, followed by the addition of a little caustic soda or zinc chloride in order to soften and partly dissolve the fiber. From such a material the entire furniture of a house could be formed by a process of molding—thus fulfilling a prophecy of H. G. Wells, as Jules Verne's dreams of the submarine and the aeroplane have already been realized.

Osmotic Pressure.

The question of electrical osmotic action or the passage of liquids through a porous diaphragm has always interested experimenters. If a porous membrane or plate of suitable material is placed in a vessel so as to divide it into two parts and we apply a current to the liquid, it is found that the liquid passes through the partition so as to rise to a higher level on one side. Conversely, if pressure is used so as to force the liquid through the diaphragm, an electric current is set up. In these cases we have an unexplained relation between osmotic action and electricity. Reuss, and afterward Perret, first observed this in the beginning of the last century, then Helmholtz took up the question. In our day Perrin and Grumbach are engaged on the subject, but the theory is obscure. It is found that the flow of liquid caused by the electric current is in inverse ratio to the viscosity and it varies directly with the electric resistance of the liquid and also to the current strength. It is thus seen that viscous liquids should not be used, as the osmose is much better with non-viscous liquids also with conducting solutions containing various salts. As an example, Perrin uses a porous substance 1.5 square centimeter (0.6 inch) square and 12 centimeters (5 inches) long and applies 25 volts. The flow of liquid, an ammonia or acetic acid solution, is 10 cubic centimeters per hour. He then makes the reverse experiment to generate current, and uses a fine sand filter of 2 square decameters (32 square inches) surface and 0.24 inch thickness and with a pressure of 80 atmospheres to force the liquid through, he obtained a current of 32 volts and 0.08 amperes. Practical uses for this action would be for depositing colors in dye processes or for drying of wet material.

Wireless Station Operated by Wind Power.—The wireless stations in Curacao are operated by wind power, and have proved to be a success. There is a central station at Curacao with a reach ordinarily of about 300 miles, and one of a smaller power on each of the islands of Bonaire and Aruba. Ordinary wind power serves, owing to the steady trade winds; but a gasoline outfit at the main station can be used when necessary.—*Brit. Trade Jour.*

Locomotive Boiler Flue Gas Analysis*

Simple Method of Finding the Weight of Gases and of Dividing the Boiler Efficiency Into Its Components

By Lawford H. Fry

In examining the efficiency of a locomotive boiler a knowledge of the weight of the smokebox gases is desirable. A method for obtaining this and other useful information from an analysis of the flue gases will now be described in detail. The methods of calculation and the reasoning on which these are based will be described concisely, but at the same time the explanations will be made as simple as possible, so that they may be followed without any profound knowledge of chemistry.

The information to be obtained by the calculations is three-fold:

First, what proportion of the coal fired escapes entirely unburned?

Second, with what efficiency does the coal burned produce heat?

Third, what proportion of the heat produced is taken up by the boiler?

The answers to the first two questions determine the efficiency of heat production, or the firebox efficiency; while the answer to the third gives the efficiency of the heat absorption, or the heating surface efficiency.

First, consider the process of combustion, in which the oxygen of the air combines with the hydrogen and with the carbon of the coal. The combination of the oxygen and carbon may occur in two ways. Expressed chemically, one method of combination is for one molecule of carbon, C, to combine with two molecules of oxygen, O, to produce one molecule of carbon dioxide CO_2. The molecule is a chemical measure which it is convenient to use for the present, but all calculations will be carried out in the usual engineering units. This process of combination may be represented by the chemical equation

$$C + 2\,O = CO_2 \qquad (1)$$

The other method of combination of oxygen and carbon is for one molecule of carbon to combine with one molecule of oxygen to form one molecule of carbon monoxide, CO. This is represented by the equation

$$C + O = CO \qquad (2)$$

The first process is the most efficient in producing heat, each pound of carbon giving 14,540 British thermal units when burned to carbon dioxide, CO_2, and only 4,360 British thermal units when burned to carbon monoxide, CO. There is therefore a loss of 10,180 British thermal units for each pound of carbon from which CO is produced, and hence every effort should be made to produce CO_2 and not CO.

Now the weights of a molecule of carbon and of a molecule of oxygen are in the proportion of 12 to 16, and hence equation (1) shows that 12 parts by weight of carbon combine with $2 \times 16 = 32$ parts of oxygen to form $12 + 32 = 44$ parts of carbon dioxide. In other words to burn 12 pounds of carbon to CO_2, 32 pounds of oxygen are required and 44 pounds of carbon dioxide are formed. That is, one pound of oxygen combines with $\frac{12}{32} = 0.375$ pounds of carbon to produce $\frac{44}{32} = 1.375$ pounds of CO_2.

Though the weight of the CO_2, or in fact of any chemical product, is the sum of the weights of the elements which combine, the same is not true of the volumes. The oxygen takes up the carbon to form CO_2 without change of volume, so that the volume of the carbon dioxide is the same as that of the oxygen which goes to form it. Consequently the production of one cubic foot of CO_2 requires one cubic foot of oxygen. This weighs 0.0888 pounds, and hence, as CO_2 is being produced, requires $0.0888 \times 0.375 = 0.0332$ pounds of carbon. That is to say 0.0332 pounds of carbon burned in one cubic foot of oxygen produces one cubic foot of CO_2.

Turning now to the conditions of combustion which produce carbon monoxide. Equation (2) and the molecular weights show that 12 pounds of carbon combine with 16 pounds of oxygen to form 28 pounds of CO. Hence one pound of oxygen burns with $\frac{12}{16} = 0.75$ pounds of carbon to form $\frac{28}{16} = 1.75$ pounds of carbon monoxide. The volume of the carbon monoxide is twice that of the oxygen which goes to form it, so that for the production of one cubic foot of CO, 0.5 cubic foot of oxygen is required. As the weight of this oxygen is 0.0444 pound, it requires, for the production of CO, $0.0444 \times 0.75 = 0.0332$ pound of carbon. Hence 0.0332 pound, of carbon burnt with 0.5 cubic foot of oxygen produces one cubic foot of CO.

Now suppose that analysis shows that in 100 cubic feet of the flue gases there are A cubic feet of carbon dioxide, CO_2, and B cubic feet of carbon monoxide, CO. The production of A cubic feet of CO_2 requires A cubic feet of oxygen and $0.0332 \times A$ pounds of carbon, while the production of B cubic feet of CO requires 0.5 B cubic foot of oxygen and $0.0332 \times B$ pounds of carbon. Hence the A cubic feet of CO_2 and B cubic feet of CO are the result of burning $0.0332\ (A + B)$ pounds of carbon in $(A + 0.5B)$ cubic feet of oxygen. Now in the atmosphere each cubic foot of oxygen is mixed with 3.76 cubic feet of nitrogen, making 4.76 cubic feet of air, so that for the above products $4.76\ (A + 0.5B)$ cubic feet of air are required.

The proportion of air to carbon is therefore

$$4.76\ (A + 0.5B) \text{ cubic feet, or } 4.76 \times 0.0808\ (A + 0.5B) = 0.384$$

$(A + 0.5B)$ pounds of air* to $0.0332\ (A + B)$ pounds of carbon or

$$\frac{0.384\ (A + 0.5B)}{0.0332\ (A + B)} = 11.52\ \frac{A + 0.5B}{A + B}$$

pounds of air per pound of carbon.†

With this proportion of air to carbon all of the oxygen combines with the carbon. If free oxygen is found in the smokebox gases it shows that more air than could be used in burning the carbon has been admitted to the furnace. Each cubic foot of oxygen corresponds to 4.76 cubic feet or 0.384 pounds of air. Hence if 100 cubic feet of the products of combustion contain M cubic feet of oxygen in addition to A cubic feet of CO_2 and B cubic feet of CO, the amount of air put into the furnace must have been $0.384\ (A + 0.5B) + 0.384\ M$ pounds, while as before the weight of carbon burned is $0.0332\ (A + B)$. This is in the proportion of $11.52 \times \frac{A + 0.5B + M}{A + B}$ pounds of air per pound of carbon.

In addition to the carbon the hydrogen of the coal is burnt, but this is a simpler process. Each pound of hydrogen combines with 8 pounds of oxygen to produce 9 pounds of water vapor. As each pound of oxygen in the air is mixed with 3.35 pounds of nitrogen, each pound of hydrogen requires $8 \times 4.35 = 34.8$ pounds of air and introduces $8 \times 3.35 = 26.8$ pounds of nitrogen into the products of combustion. Now consider the application of the foregoing to an actual case and examine the conditions under which the dry coal and the dry products of combustion have the following analyses:

Analysis of Dry Coal by Weight.

		Per cent.
Carbon (C)	=	83.0
Hydrogen (H)	=	5.0
Oxygen (O)	=	3.5
Nitrogen (N)	=	1.0
Ash (A)	=	7.5
Total		100.0

Analysis of Dry Smoke-Box Gases by Volume.

		Per cent.
Carbon dioxide (CO_2) A	=	12.0
Carbon monoxide (CO) B	=	0.4
Free oxygen (O_2) M	=	6.0
Nitrogen (N)	=	81.6
Total		100.0

The air consumed per pound of carbon burned is

$$11.52\ \frac{12.0 + 0.5 \times 0.4 + 6.0}{12.0 + 0.4} = 11.52 \times \frac{18.2}{12.4} = 16.9 \text{ lbs.}$$

and as each pound of coal contains 0.83 pounds of carbon the air required for the combustion of this element is $0.83 \times 16.9 = 14.0$ pounds per pound of coal burned. In each pound of coal 0.05 pounds of hydrogen are found, requiring for combustion $8 \times 0.05 = 0.40$ pounds of oxygen. As the pound of coal contains in itself 0.035 pounds of oxygen, it is only necessary to take from the atmosphere $0.40 - 0.035 = 0.365$ pounds of oxygen corresponding to $0.365 \times 4.35 = 1.585$ pounds of air and $0.365 \times 3.35 = 1.220$ pounds of nitrogen. Now the dry products of combustion are composed of the carbon in the coal and the air used in its combustion, together with the nitrogen of the air used to burn the hydrogen, and the nitrogen in the coal. Hence for each pound of coal burned the weight of the dry products of combustion will be:

	Pounds.
Carbon	0.83
Air for combustion of carbon	14.00
Nitrogen from combustion of hydrogen	1.22
Nitrogen in coal	0.01
Total	16.06

This examination of the amount of air employed in combustion, and the determination therefrom of the weight of the dry smokebox gases, is given for the sake of completeness, but for practical work I have developed a much simpler method of calculation. I find that with the analyses obtained in locomotive practice it is permissible to take the weight of 100 cubic feet of dry smokebox gases, as 8.30 pounds. Now, 100 cubic feet of dry gas has been seen to result from the combustion of $0.0332\ (A + B)$ pounds of carbon, and hence for each pound of carbon burned $\frac{8.30}{0.0332\ (A + B)} = \frac{250}{A + B}$ pounds of dry gas will be produced. In the present case each pound of carbon burned will produce $\frac{250}{12.0 + 0.4} = 20.1$ pounds of dry gas, and as each pound of coal contains 83 per cent of carbon the weight of dry gases per pound of coal will be $20.1 \times 0.83 = 16.7$ pounds. The result is not quite the same as that obtained by the other method, but both methods have about equal claims to accuracy, and the difference between the results will not exceed the probable experimental error.

In addition to the above dry products of combustion the flue gases will contain the water vapor produced by the combustion of the hydrogen and that due to the moisture in the coal and air. Under the conditions assumed above the hydrogen produces nine times its weight, or 0.45 pounds of water per pound of coal burned, and if the moisture from the air be 1 per cent of the weight of the coal, the total weight of water will be $0.45 + 0.01 = 0.46$ pounds per pound of coal burned. This water vapor leaves the smokebox in the form of highly superheated steam, and thus carries off the heat required for its evaporation and superheating. If the smokebox temperature be 700 deg. Fahr., and the temperature of the water on entering the firebox is 70 deg. Fahr., the heat required per pound will be $212 - 70 = 142$ British thermal units to raise it to boiling point, 966 British thermal units for evaporation, and, say, $0.48\ (700\text{-}212) = 0.48 \times 488 = 234$ British thermal units for superheating, making a total of $142 + 966 + 234 = 1{,}342$ British thermal units per pound of moisture, or $0.46 \times 1{,}342 = 600$ British thermal units per pound of coal fired.

As the specific heat of the dry products of combustion in the smokebox is approximately 0.24, the heat carried by them under the conditions assumed above will be $16.06 \times 0.24 \times (700\text{-}70) = 2{,}420$ British thermal units per pound of coal burned. If the coal has a heating value of 14,500 British thermal units, the 600 British thermal units carried by the water vapor will be 4.1 per cent, and the 2,420 British thermal units carried by the dry gases, 16.7 per cent, or a total of 20.8 per cent of the heat of each pound of coal burned will be carried off in the smokebox gases.

Now consider the production of the heat. In the first place the appearance of CO instead of CO_2 entails a loss, amounting as seen, to 10,180 British thermal units per pound of carbon burned to CO; when the smokebox gases contain A cubic feet of CO_2 and B cubic feet of CO per 100 cubic feet, it has been seen that $0.0332 \times A$ pounds of carbon are burned to produce the CO_2 and $0.0332 \times B$ pounds of carbon to produce the CO, so that the fraction of the total carbon which is burnt to CO is $\frac{0.0332\,B}{0.0332\ (A + B)} = \frac{B}{A + B}$, and the loss on each pound burned is $10{,}180\ \frac{B}{A + B}$ British thermal

* One cubic foot of air weighs 0.0808 pounds.

† It will be seen that if no CO is produced B will be zero and 11.52 pounds of air will be used per pound of carbon, CO_2 being alone produced. If on the other hand no CO_2 is produced A will be zero and 5.56 pounds of air will be used, CO being the only product of combustion.

* Reproduced from the *Railway Age Gazette*.

units, or in the present case $10{,}180 \dfrac{0.4}{12.0 + 0.4} = 328$ British thermal units per pound of carbon, or $0.83 \times 328 = 272$ British thermal units per pound of coal burned. This is 1.9 per cent of the heating value of the coal, and consequently only $100 - 1.9 = 98.1$ per cent of the heating value of the coal burned is effective in the firebox. It has also been seen that 20.8 per cent of the heating value of the coal burned is carried away by the smokebox gases. The remainder $98.1 - 20.8 = 77.3$ per cent of the heat of the coal burned is to be accounted for by the heat lost by reason of moisture in the coal, by the heat employed in evaporation, and by the heat lost by external radiation, leakage of steam, etc. The loss due to the moisture in the coal is a very small quantity, which is usually negligible in practice, and is only considered here for the sake of completeness.

As before stated, each pound of moisture carries 1,302 British thermal units out of the smokebox. Hence, if the coal fired contains 4 per cent of its own weight of moisture, this will cause a loss of $0.04 \times 1{,}302 = 52$ British thermal units, or 0.36 per cent of the heating value of the coal fired.* The heat employed in evaporation is easily determined from the weight and temperature of the steam produced. For the present case suppose it to amount to 65 per cent of the heat in the coal fired, and suppose that the heat lost by external radiation, etc., is 3 per cent of the heat of the coal fired. Then the heat taken up by the heating surface, which was shown to be 77.3 per cent of that of the coal *burned*, is the same as $65 + 3 + 0.36 = 68.36$ per cent of the heat of the coal *fired*. Hence 1 per cent of the coal burned is equivalent to $\dfrac{68.36}{77.3} = 0.884$ per cent of that fired, so that the total heat in the coal burned is 88.4 per cent of that of the coal fired, while $100 - 88.4 = 11.6$ per cent of the heat of the coal fired is lost by the escape of unburned combustible. We have now determined the distribution of the heat of the coal fired to be:

	Per cent of the heat in coal fired.
Heat employed in evaporation	65.00
Heat lost by external radiation, etc..........	3.00
Heat lost by moisture in coal fired..........	0.36
Heat lost by coal escaping unburned.........	11.60
Heat lost by production of CO; 1.9 per cent of heat of coal burned = 1.9 × 0.884 =......	1.68
Heat lost in dry gases of combustion; 16.7 per cent of heat of coal burned = 16.7 × 0.884 =	14.74
Heat lost in water of combustion; 4.1 per cent of heat of coal burned = 4.1 × 0.884 =....	3.62
Total	100.00

Grouping these items in another way we have:

	Per Cent.	Per Cent.
Heat in coal fired		100.00
Heat lost by coal escaping unburned	11.6	
Heat lost by production of CO......	1.68	13.28
Heat actually produced in firebox...........		86.72
	Per Cent.	
Heat lost by moisture in coal......	0.36	
Heat lost by water of combustion...	3.62	
Heat lost by dry gases of combustion	14.74	18.72
Heat taken up by heating surface...........		68.00
Heat lost by external radiation...........		3.00
Heat effectively used in evaporation		65.00

From this it follows that the heat actually produced being 86.72 per cent, and the heat taken up by the heating surface 68 per cent of that of the coal fired, the heat taken up is $100 \times \dfrac{68}{86.72} = 77.2$ per cent of that produced. Hence the efficiency of the combustion is found to be 86.72 per cent, the efficiency of heat absorption 77.2 per cent, and the over-all boiler efficiency 65 per cent. To collect the information which has been obtained, in convenient form for reference, and for general use, it will now be briefly summed up and put into the shape of formulæ. If the coal and flue gas analyses are:

Analysis of Dry Coal by Weight.

	Per Cent.
Carbon	C_1
Hydrogen	H_1
Oxygen	O_1
Nitrogen	N_1
Ash	As_1
Total	100.00

* Note that hitherto we have been referring the heat losses to the coal *actually burned*. We now begin to refer to the coal *fired*, and the relation between coal fired and coal burned will be determined.

Analysis of Dry Flue Gases by Volume.

	Per Cent.
Carbon dioxide (CO_2)	A
Carbon monoxide (CO)	B
Oxygen (O)	M
Nitrogen (N)	D
Total	100.00

If the heating value of the dry coal be K. British thermal units per pound; the temperature of the smokebox ts deg. Fahr., and the temperature of the air ta deg. Fahr. Then the weight of air supplied per pound of coal actually burned will be:

$$Ac = 11.32 \times \frac{A + 0.5B + M}{A + B} \times \frac{C_1}{100} \qquad (3)$$

and the nitrogen left from the combustion of the hydrogen per pound of coal burned will be:

$$Nhc = 0.0335\ (8\ H_1 - O_1) \qquad (4)$$

The total weight of dry products of combustion per pound of dry coal burned will be:

$$Wg = \frac{C_1}{100} + \frac{N_1}{100} + Ac + Nhc \qquad (5)$$

that is, the sum of the carbon and nitrogen of the coal, together with the air passed through the fire to burn the carbon and to provide the free oxygen, and the nitrogen left from the combustion of the hydrogen; or by the approximate method described above the weight of the dry products of combustion per pound of coal burned will be

$$Wg = 2.5 \frac{C_1}{A + B} \qquad (5a)$$

The dry gases escape at the smokebox temperature and the specific heat being taken as 0.24, the consequent loss of heat expressed as a percentage of the heat of the coal burned is:

$$Bw_1 = \frac{24\ (ts - ta)\ Wg}{K} \qquad (6)$$

The water vapor produced by the combustion of the hydrogen per pound of coal is:

$$Wm = 9\ H_1 \qquad (7)$$

and the heat lost by the escape of this vapor at the smokebox temperature as a percentage of the heating value of the coal burned is:

$$Bv_1 = \frac{9\ H_1}{K}\ (1076 + 0.48\ ts - ta) \qquad (8)$$

Further losses are incurred by the escape of the water vapor produced from the moisture of the air and of the coal, but unless the amount of this moisture is excessive, say over 10 per cent of the weight of the coal, the loss thus produced is negligible. Then the loss in the products of combustion, wet and dry, expressed as a percentage of the heat of the coal burned is $B_{w_1} + B_{v_1}$.

The loss of heat production due to the formation of CO, if expressed as a percentage of the heat of the coal burned is

$$U_1 = 10{,}180 \frac{B}{A + B} \times \frac{C_1}{K_1} \qquad (9)$$

Again if P_2* per cent of the coal fired escapes unburned, the coal burned will be $(100 - P_2)$ per cent of that fired. Of this coal burned it has been seen that U_1 per cent of heat is lost in the production of CO and $B_{w_1} + B_{v_1}$ per cent is carried off in the products of combustion, so that the remainder, which is taken up by the heating surface, is $100 - U_1 - B_{v_1} - B_{w_1}$ per cent of the heat of the coal burned, or $\dfrac{100 - P_2}{100}$ $(100 - U_1 - B_{v_1} - B_{w_1})$ per cent of the heat of the coal fired.

On the other hand if, as may be ascertained by measurement, T_2 per cent of the heat of the coal fired is utilized in evaporating the water, and R_2 per cent is lost by external radiation and leakage, $T_2 + R_2$ per cent of the heat of the coal fired is taken up by the boiler, and this can be equated to the expression above.

$$\text{Then} \qquad T_2 + R_2 = \frac{100 - P_2}{100}\ (100 - U_1 - Bv_1 - Bw_1)$$

$$\text{and} \qquad 100 - P_2 = \frac{100\ (T_2 + R_2)}{100 - U_1 - Bv_1 - Bw_1} \qquad (10)$$

and since all of the quantities except P_2 can be calculated from the foregoing or measured, equation (10) enables P_2, that is the coal lost unburned, to be calculated. It may be noted that in practice it is not easy to measure R_2, that is the percentage of heat lost by external radiation, leakage, etc., but it is certain that no great error will be made if it is assumed to be 5 per cent of T_2, the heat used in the production of the steam. With this assumption equation (10) gives an easy method of arriving at the value of P_2, a quantity which is far from easy of direct measurement. To obtain a complete account of the heat of the coal fired it is only necessary to multiply U_1, B_{v_1} and B_{w_1} by $\dfrac{100 - P_2}{100}$ to express the losses represented by these symbols as percentages of the heat of the coal fired.

* The subscript $_1$ is used for quantities which are expressed as a percentage of the heat in the coal *burned*, while the subscript $_2$ is used where the quantities are expressed as percentages of the heat in the coal *fired*.

The previous article showed a practical application of the methods of analysis which have since been described, and a little consideration will show that this is only one instance out of many of the advantages to be derived from a study of locomotive tests in which flue gas analyses are made. At present the published information regarding tests of this description is strictly limited, but in view of the importance of the information to be obtained it is to be hoped that the taking of flue gas analyses will soon come to be a regular part of any locomotive test. A simple method of sampling for such analyses during a road test was described by Dr. F. J. Brislee before the Institution of Mechanical Engineers in London, on March 27th, 1908. A 1-inch iron tube was run horizontally across the center of the smokebox in front of the exhaust pipe. The end of the tube inside the smokebox was closed, and a saw cut about an ⅛ inch wide was made along the tube on the side nearest the boiler flues. Outside the smokebox the tube connected to a ½-inch pipe which led along the handrail back of the cab. The gases were drawn into the tube and back to the cab by means of a bellows type of aspirator, and after being filtered through asbestos fiber were collected in glass tubes of about 100 cubic centimeters (6.1 cubic inches) capacity, fitted at each end with a well ground glass tap. With an apparatus of this description it is easy to take samples of gas at intervals throughout a locomotive test and to have them analyzed at the end of the run. In this way much valuable information regarding the conditions of combustion can be obtained.

A Special Course in Petroleum Mining, leading to the degree of B.Sc. (in petroleum mining) is to be established at Birmingham University, England, in order to supply the pressing demand for experts in this field. Installations of the percussion and rotary systems of drilling will be provided in the grounds of the university in order to provide practical demonstration of boring operations.

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